UNIVERSITY OF KANSAS
PALEONTOLOGICAL CONTRIBUTIONS

MOLLUSCA

ARTICLE 4
Pages 1-38, Plates 1-5, Figures 1-15

ILLINOIAN AND WISCONSINAN MOLLUSCAN FAUNAS IN KANSAS

By A. BYRON LEONARD

UNIVERSITY OF KANSAS PUBLICATIONS

FEBRUARY 15, 1952

PRINTED BY
FERD VOILAND, JR., STATE PRINTER
TOPEKA, KANSAS
1952

24-392

UNIVERSITY OF KANSAS
PALEONTOLOGICAL CONTRIBUTIONS

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UNIVERSITY OF KANSAS PALEONTOLOGICAL CONTRIBUTIONS
MOLLUSCA, ARTICLE 4, PAGES 1-38, PLATES 1-5, FIGURES 1-15

ILLINOIAN AND WISCONSINAN MOLLUSCAN FAUNAS IN KANSAS

By A. BYRON LEONARD [1]

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ILLUSTRATIONS

1. Professor of Zoology, University of Kansas; Paleontologist, State Geological Survey of Kansas, Lawrence.

ABSTRACT

Pleistocene deposits of Illinoian and Wisconsinan ages in Kansas are classed as members of the Sanborn formation. Sediments of Illinoian age within the State include the Crete sands and gravels, overlain by the Loveland silt member, in which is developed the Sangamon buried soil. Deposits of Wisconsinan age include the Peoria silt member, in which the Brady buried soil is developed, and above this, the Bignell silt, in which the modern soil profile is developed.

A distinctive molluscan faunal assemblage is found in Crete-Loveland sediments; the Peoria silt bears a series of faunal assemblages correlated with those in Farmdale, Iowa, and Tazewell loesses, elsewhere. The Bignell silt possesses a molluscan fauna which is essentially Recent in age. The Bignell silt in Kansas is not divisible into components of Caryan and Mankatoan ages, but the well-developed modern soil developed in the Bignell silt suggests that, for the most part at least, these silts are as old as Caryan.

It is well known that the mollusks which characterize the post-Yarmouthian, pre-Bradyan faunal assemblages require a moist ground litter of vegetation for reproduction, feeding, and growth. It is concluded, therefore, that the great region of loess deposition in the Great Plains was well covered with grasses, herbs, and shrubs during the periods of loess accumulation.

INTRODUCTION

A conspicuous feature of the post-Yarmouthian Pleistocene deposits in Kansas is the great abundance and variety of fossil mollusks contained in many of them. The shells of mollusks are so plentiful in many of these sediments (except where they have been destroyed by soil-forming processes) that the shells form a prominent aspect of the lithology of the sediments. In numerous exposures as many as 5,000 shells per cubic foot of matrix have been noted, together with a variety of kinds exceeding by several fold the number of species now living in the vicinity. Everywhere in the State, but especially in central and western parts of Kansas where late Pleistocene deposits are less severely affected by weathering processes than in the eastern one-third of the State, assemblages of fossil mollusks greatly exceed in variety of species, and presumably also in population density, the local living molluscan fauna. The greater part of the fossil molluscan fauna of Illinoian and Wisconsinan deposits in Kansas is either extinct or no longer living in the mid-continent region. A considerable number of genera no longer have species in the State, whereas others are represented by species different from those occurring here in Pleistocene times. These facts, together with the occurrence of distinctive molluscan assemblages in each of the post-Yarmouthian stratigraphic units in Kansas, provides the Pleistocene stratigrapher with a valuable tool for his studies and enables the paleoecologist to draw conclusions as to climatic conditions prevalent during each of the several episodes of late Pleistocene time. The importance and usefulness of the molluscan assemblages is emphasized by the extreme paucity of vertebrate fossils in post-Yarmouthian sediments in Kansas. While vertebrate fossils forming characteristic faunas are to be found in these deposits, the occurrence of vertebrate remains is so infrequent and unpredictable that they are of small value for field studies of stratigraphy.

Post-Yarmouthian Pleistocene deposits in Kansas consist primarily of a series of loess sheets, each of which has a soil profile developed within its upper part. These loesses, which are best developed and preserved on divide areas in central and western parts of the State, are so thin as to be scarcely recognizable in eastern Kansas, except in the northern tier of counties, especially near the Missouri River,

where great thicknesses are common (FRYE *et al.*, 1949, p. 57). East of the Flint Hills at a distance of only a few miles from the Missouri River, the loess is generally so thin that it is entirely involved in the modern soil profile; it is nonfossiliferous, and subdivision is almost impossible.

STRATIGRAPHIC CLASSIFICATION

In the classification of the State Geological Survey, these widespread loess sheets, together with associated fluviatile deposits, are classed as members in the Sanborn formation (Fig. 1). Excluded

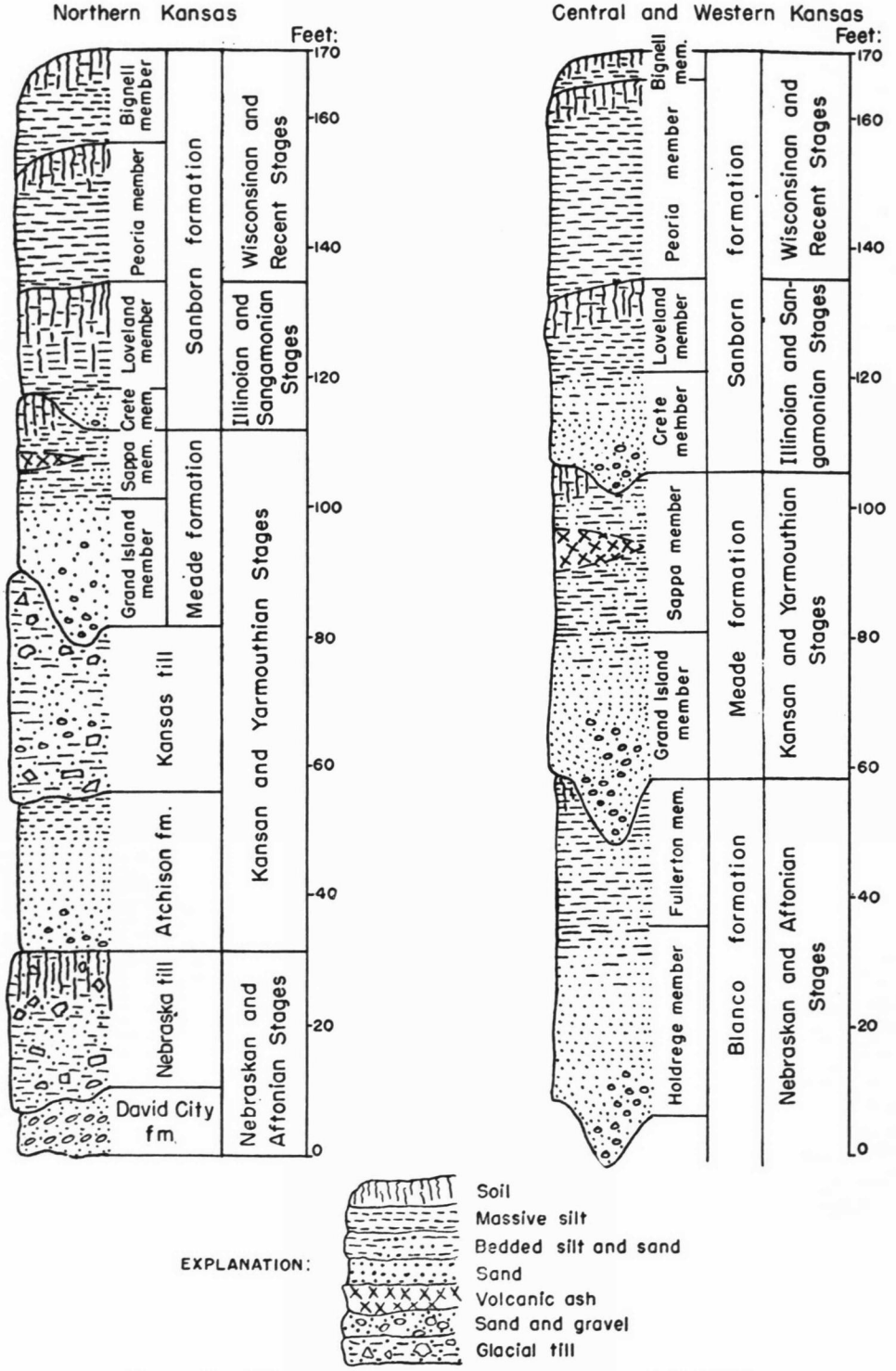


FIGURE 1.—Pleistocene rocks in Kansas (from MOORE *et al.*, 1951).

are materials of the principal terraces in valleys, which generally are mapped as physiographic entities, and colluvial veneers of indeterminate age. Four members of the Sanborn are recognized. The oldest, comprising Crete sands and gravels, rests unconformably on the Yarmouthian soil, locally with channels cut into it or the underlying Sappa silts. Next to oldest is the Loveland silt or loess, in which is developed the Sangamon soil. The upper two members are the Peoria silt, terminating upward in the Brady soil, and the Bignell silt, in which the modern soil profile has formed. It is the purpose of this paper to describe the assemblage of fossil mollusks found in each member of the Sanborn formation, with discussion of their stratigraphic significance and paleoecology.

The Sanborn formation was named by ELIAS (1931, p. 163), who defined it as "the loess, with some sand and gravel at the base, which is widely distributed on the divides in western Kansas." The exposures upon which ELIAS mainly based his studies occur in deep canyons on the south side of the Arikaree River valley in extreme northwestern Kansas; no type section was originally designated, but later ELIAS agreed that exposures in the NW¼ sec. 20, T. 1 S, R. 41 W., Cheyenne County, Kansas, were typical and satisfactory as a type section (FRYE & FENT, 1947, p. 41).

The widespread occurrence of loess in central and western Kansas has been known for many years. HAY (1895, p. 574) described a "Plains marl" which "has been called loess by geologists both of Nebraska and Colorado." HAWORTH (1897, p. 275), referring to the plains marl of HAY, stated that "In general character, this is surprisingly similar to the glacial loess so well known in many parts of the world. . . . It is probable that many of the properties of the plains marl are largely due to the action of wind." MOORE & LANDES (1927, p. 32) treated the loess in Kansas as a separate post-Tertiary formation.

LUGN (1935, p. 128 ff.), in a general bulletin on Pleistocene geology of Nebraska, divided post-Yarmouthian deposits of that State into two formations, the Loveland silt formation, not restricted to deposits of upland areas, and the Peorian formation. LUGN recognized the soil in the upper part of the Loveland as evidence of an unconformity.

Subdivision of the Sanborn formation in Kansas was not at first attempted. A. B. LEONARD & FRYE (1943, p. 454) stated that in most exposures "It is gradational from top to bottom," although ELIAS (1937, p. 7) had recognized Loveland loess in northern Decatur County. In a reconnaisance report on the Pleistocene of northwestern Kansas, HIBBARD, FRYE, & A. B. LEONARD (1944, p. 6) distinguished the Loveland and Peoria loesses, commented upon the Loveland soil, and made tentative correlations with the Loveland and Peorian of Nebraska. SCHULTZ & STOUT (1945, p. 231), in a study of the loesses of Nebraska, recognized three post-Yarmouthian stratigraphic units, separated by unconformities consisting of soil profiles, and each of these units was given formational status. They are (1) the Loveland loess, in which is developed what was then called the "*Citellus* zone soil"; (2) the Peorian loess, terminating above in "soil X" (later named by them Brady soil, 1948, p. 570); and (3) the Bignell loess at the upland surface.

FRYE & FENT (1947, p. 42) appreciated the significance of weathered zones in the loesses of Kansas as representing ancient soils, and on the basis of them defined three members in the Sanborn formation. They were called the Loveland silt member, terminating above in the Loveland soil (equivalent of the *Citellus* zone soil of SCHULTZ & STOUT, but now properly called the Sangamon soil); the Peoria silt member; and the Bignell silt member. These members were correlated with the similarly named formations in Nebraska.

LUGN (1935, p. 130) described a "valley phase" of the Loveland formation, consisting of silts, clay, sands, and gravels. These were given a new name and formational rank (Crete formation) by CONDRA, REED, & GORDON (1947, p. 24).

The basal sands and gravels in the Sanborn formation were judged by FRYE *et al.* (1949, p. 57) and FRYE & A. R. LEONARD (1949, p. 42) to be the equivalent of the Crete formation of Nebraska classification. Accordingly, they gave member status in the Sanborn formation to sands and gravels which rest unconformably upon the Sappa member of the Meade formation and below Loveland silt, in terraces in the valley of Prairie Dog Creek, and elsewhere, in northwestern Kansas.

The stratigraphic position, age, and correlation of the four members of the Sanborn formation have been discussed recently by FRYE & A. B. LEONARD (1951), with notation of the molluscan faunas found in these sediments but without detailed description of them.

METHODS OF STUDY

The field studies which form the basis of this report were begun in the summer of 1948 and have continued to the present time. Literally hundreds of exposures (Fig. 2) in the State and a much smaller number in neighboring states have been examined. About 100 localities, selected because of the excellence of their contained molluscan assemblages, or because of their limital position with respect to distribution of some stratigraphic unit, are discussed here. Local exposures in which the stratigraphic placement was not entirely clear have been excluded. I am grateful to JOHN C. FRYE, of the State Geological Survey, and to A. R. LEONARD, of the United States Geological Survey, for their assistance in confirming the stratigraphic position of

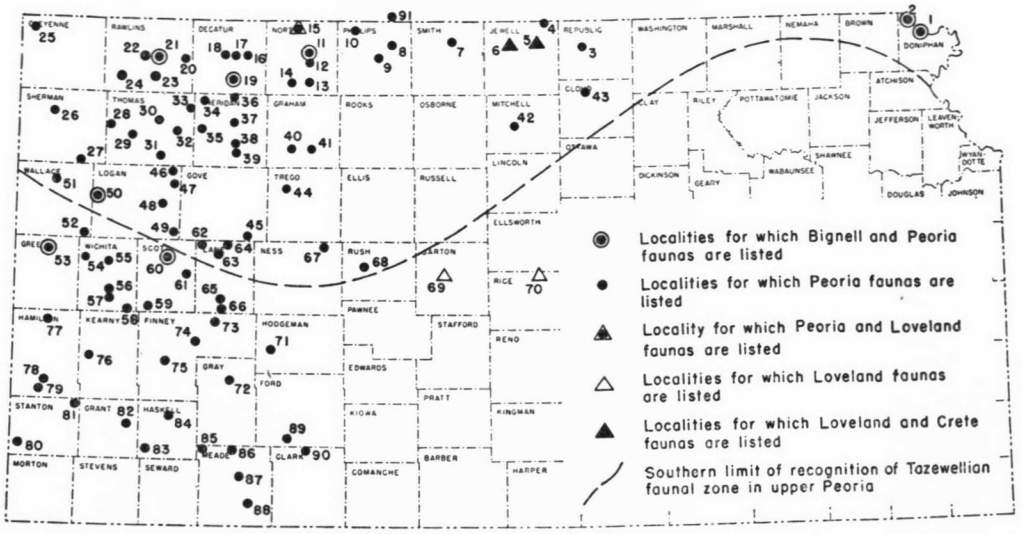


FIGURE 2.—Localities in Kansas at which Illinoian and Wisconsinan molluscan faunas were collected.

nearly all local exposures utilized in this report.

Several techniques were used in collecting the fossils from the several local exposures of Pleistocene sediments. Most commonly sediments were washed through screens (24-mesh) which allowed silts and clays to pass through, while retaining even the smallest shells. The residue on the screen was then dried, and the shells sorted from other particles, such as sand grains, caliche nodules, roots and other debris. About 100 pounds of fossiliferous sediment made up the average sample, when feasible, although it was frequently necessary to collect smaller samples; and in a number of cases, much larger samples were studied.

Occasionally, collections were limited to shells picked up from the surface of a weathered exposure if it was clear that the shells could come only from the stratigraphic unit with which they were associated. This method was compared, on a number of occasions, with the results obtained by washing a quantity of fossil-bearing sediment through screens. It is my judgment that with careful hand-picking a skilled collector can obtain about 90 percent of the species occurring in a deposit, but in much smaller numbers, of course, than can be obtained by bulk methods. The larger series of specimens is valuable for study later, and hand-picking of shells is not advised if quantities of matrix can be obtained.

In certain areas of the State, the topography consists of an almost undissected plain. Numerous hand-auger holes were drilled in these areas to explore the local Pleistocene stratigraphy. In a number of instances, these auger cuttings (from a 3-inch auger) were washed through screens and characteristic molluscan assemblages recovered.

In the laboratory, shells recovered from screening or hand collecting were sorted to kind, identified, and catalogued in the Molluscan Collections of the University of Kansas Museum of Natural History. Pleistocene mollusks are arranged according to their strata of origin, and are available for study by qualified persons who may be interested.

CRETE-LOVELAND MOLLUSCAN FAUNAS

The Crete member of the Sanborn formation was described by CONDRA, REED, & GORDON (1947, p. 24) as the Crete formation from sand and gravel deposits near Crete, Saline county, Nebraska. These authors state: "The Crete formation is a channel fill deposit which rests unconformably upon the Upland formation [= Sappa formation] or older Pleistocene deposits and is believed to be Illinoian in age. . . . In general the Crete formation is limited in its occurrence to channels associated with but generally broader than our present well-developed valleys." The Loveland member of the Sanborn formation was described by SHIMEK (1909) from deposits of fine, well-sorted silt exposed in the bluffs of the Missouri River, just northeast of Loveland, Pottawatamie County, Iowa. At the type locality, the Loveland consists of eolian silts, which are fossiliferous in the lower part. It follows, of course, that the fluviatile phase of the Loveland is generally associated with ancient valleys, while the eolian phase is best preserved on the highest elements in the present topography.

No unconformity is recognizable between the Crete and Loveland members where both are present in depositional sequence, and it is for this reason that the two are considered together. Typically, the Crete sands and gravels grade upward into fluviatile silts, which in turn grade into massive,

well-sorted silts, judged to be eolian in origin. In fact, the distinction between Crete and Loveland is an arbitrary one, although extremes of the depositional sequence—sands and gravels on the one hand, and well sorted massive silts on the other—present no difficulties in field studies.

Species	Sappa	Crete-Loveland	Peoria-Lower	Peoria-Upper	Bignell
Anguispira alternata					●
Stenotrema monodon aliciae					●
Triodopsis albolabris					●
Vallonia pulchella	●				●
Gastrocopta armifera	●	●		●	●
Hendersonia occulta	●			●	●
Succinea grosvenori	●	●		●	●
Succinea ovalis	●			●	●
Hawaiia miniscula	●	●	●	●	●
Helicodiscus parallelus	●	●	●	●	●
Gastrocopta holzingeri	●	●		●	
Columella alticola				●	
Striatura milium				●	
Vertigo coloradensis				●	
Vertigo modesta	●			●	
Carychium exiguum	●	●		●	
Cionella lubrica	●			●	
Pupilla blandi	●	●	●	●	
Discus cronkhitei	●	●		●	
Discus shimeki				●	
Vertigo tridentata	●	●	●	●	
Euconulus fulvus			●	●	
Helicodiscus singleyanus			●	●	
Vertigo gouldi paradoxa	●		●	●	
Vertigo milium	●		●	●	
Deroceras laeve		●	●	●	
Pupilla muscorum	●	●	●	●	
Retinella electrina	●	●	●	●	
Zonitoides arboreus	●	●	●	●	
Vallonia gracilicosta	●	●	●	●	
Succinea avara	●		●		
Lymnaea parva	●		●		
Helisoma trivolvis	●	●			
Physa anatina	●	●			
Pupoides albilabris	●	●			
Strobilops labyrinthica		●			
Carychium perexiguum	●	●			
Gastrocopta cristata	●	●			
Gyraulus similaris	●	●			
Helisoma antrosa	●	●			
Sphaerium solidulum	●	●			
Gastrocopta tappaniana	●	●			
Strobilops sparsicosta	●	●			
Vertigo ovata	●	●			
Ferrissia parallela	●				
Gastrocopta contracta	●				
Gastrocopta falcis	●				
Gastrocopta procarmifera	●				
Gastrocopta procera	●				
Amnicola limosa parva	●				
Gastrocopta tridentata	●				
Gyraulus labiatus	●				
Gyraulus pattersoni	●				
Helisoma wisconsinensis	●				
Lymnaea bulimoides	●				
Lymnaea caperata	●				
Lymnaea palustris	●				
Lymnaea reflexa	●				
Polygyra texasiana	●				
Menetus pearlettei	●				
Oxyloma navarrei	●				
Physa elliptica	●				
Pisidium compressum	●				
Planorbula nebraskensis	●				
Planorbula vulcanata vulcanata	●				
Planorbula vulcanata occidentalis	●				
Pomatiopsis concinnatiensis	●				
Promenetus umbilicatellus	●				
Pupilla muscorum sinistra	●				
Stenotrema monodon monodon	●				
Aplexa hypnorum	●				
Valvata lewisi	●				
Valvata tricarinata	●				
Deroceras aenigma	●				

FIGURE 3.—Molluscan assemblages of the Sappa silts (late Kansan and early Yarmouthian age), Crete-Loveland sequence of gravels, sands, and silts (Illinoian age); lower (Iowan) and upper (Tazewellian) faunal zones of the Peoria loess (early Wisconsinan age); and Bignell loess (post-Bradyan age).

The Crete and Loveland members of the Sanborn formation are the depositional representatives of Illinoian time in Kansas. The stratigraphic placement of these deposits is well established and is shown with especial clarity by relations in north-central counties of the State (FRYE & A. R. LEONARD, 1949, p. 43). Here the Crete rests unconformably on sediments of the Sappa member of the Meade formation, which have been shown clearly to be latest Kansan or earliest Yarmouthian in age (FRYE, SWINEFORD & LEONARD, 1948, p. 521, fig. 3). The Sappa silts, which have been traced into the Pleistocene sequence of deposits in the glaciated region of the Missouri Valley, have been widely and firmly correlated (Fig. 3) on faunal (LEONARD, 1950) and physiographic evidence, and particularly on distinctive lithologic properties of its contained Pearlette volcanic ash (SWINEFORD, 1946). The Crete-Loveland sediments terminate above in the Sangamon buried soil, which lies unconformably below the Peoria silt, shown to be earliest Iowan in age in its basal part (LEONARD, 1951). Thus, the Crete-Loveland sequence of deposits is clearly bounded below by sediments of Kansan age and limited above by sediments of earliest Iowan age. Molluscan faunas from Crete-Loveland deposits have not been traced into direct association with Illinois glacial till, but the stratigraphic evidence leaves no doubt of the Illinoian age of the Crete-Loveland sediments.

Crete-Loveland deposits in Kansas are only locally fossiliferous for reasons not completely understood, although certain factors bearing upon the phenomenon are more or less obvious. The Sangamon soil is deeply developed; in fact, this weathered zone is so conspicuous that it is the most widespread and easily recognized physical feature in the late Pleistocene deposits of the State. The deep weathering of the Sangamon soil is inimical to the preservation of mollusk shells which formerly may have been present in Crete-Loveland sediments; commonly the Sangamon soil profile involves the total thickness of these deposits. The environmental con-

Species	Locality Number					
	5	6	15	69	70	97
Anodonta sp.		●				
Carychium exiguum	●					
Carychium perexiguum				●	●	
Deroceras laeve					●	
Discus cronkhitei						●
Gastrocopta armifera	●					●
Gastrocopta holzingeri						●
Gastrocopta tappaniana		●				
Gyraulus similaris	●			●		
Hawaiia miniscula	●					
Helicodiscus parallelus	●	●				
Helicodiscus singleyanus	●					
Helisoma antrosa	●				●	
Helisoma trivolvis lentum	●	●				
Physa anatina	●				●	
Pupilla blandi		●				
Pupilla muscorum			●			
Pupoides albilabris	●	●				
Retinella electrina				●		
Sphaerium solidulum	●	●		●		
Strobilops sparsicosta					●	
Strobilops sp.						●
Succinea grosvenori	●	●	●	●		●
Vallonia gracilicosta	●	●	●			●
Vallonia pulchella	●					
Vertigo ovata						●
Vertigo tridentata			●			
Total number species	14	9	4	5	5	7

FIGURE 4.—Molluscan species from Crete-Loveland gravels, sands, and silts at six localities. Locations are shown on Figure 2, except locality 97, which is the type exposure of the Loveland loess, at Loveland, Iowa.

ditions prevalent during deposition of sands and gravels, such as those in the Crete, are also unfavorable to the preservation of shells, because these fragile objects cannot withstand the abrasive action of coarse clastics in motion. Finally, the climate during Illinoian time may have been unfavorable to mollusks, but this seems unlikely in view of the kinds of mollusks known to have been present at least locally. The paucity of molluscan remains in unleached, apparently unmodified Lovelandian sediments, remains largely unexplained, although additional evidence is discussed later.

The molluscan assemblage known from Illinoian (Crete-Loveland) deposits in Kansas, including species found in unweathered loess at the base of the type section of the Loveland formation in northwestern Pottawattamie County, Iowa, comprises 27 species, which are tabulated in Figure 4. In general, the assemblage is intermediate in character between that from the Sappa silts, stratigraphically below Crete-Loveland sediments, and that from the Peoria silts, stratigraphically above.

In spite of its intermediate character, the Crete-Loveland fauna has a number of distinctive features worthy of note.

(1) Fourteen species, of common occurrence in Sappa silts, do not appear in Crete-Loveland sediments. None of the genera of branchiate gastropods, such as *Amnicola, Pomatiopsis,* and *Valvata,* survived the Yarmouthian interglacial interval in the mid-continent region. Likewise, pulmonate gastropods, such as *Planorbula, Menetus, Promenetus, Ferrissia,* most species of *Gyraulus,* and large species of *Lymnaea,* failed to survive the ecological changes that followed the close of deposition of the Sappa silts.

(2) Four species, commonly found in Sappa silts, make their last appearance in the geologic column in Crete-Loveland deposits; these are *Carychium perexiguum, Strobilops sparsicosta, Gyraulus similaris,* and *Helisoma antrosa.* The first two species are now extinct, *G. similaris* occurs in relict populations in a few lakes in the Front Range of the Rocky Mountains, and *H. antrosa,* while extinct on the Great Plains, is still a common snail in the humid regions of central and eastern United States.

(3) At least two species, *Columella alticola* and *Striatura milium,* which are relatively common in the Wisconsinan loess (Tazewellian zone of the Peoria silt), are not found in Crete-Loveland deposits in the State.

It is difficult to escape the conclusion that a profound change in ecological conditions in the Great Plains region occurred at the close of the Yarmouthian interglacial interval or at the beginning of the Illinoian cycle of erosion. Dramatic extinction of the great populations of branchiate and other gastropods adapted to life in permanent water, which thrived in western Kansas in late Kansan and early Yarmouthian times, is indicative of a less humid environment and of less heavily alluviated valley systems in the Great Plains region. The assemblage of aquatic gastropods in the Sappa silts, the prevalence in these sediments of the zygospores of some *Chara*-like alga, and abundance of the valves of ostracodes, all point toward an environment of permanent, slow-flowing or ponded water, without excessive siltation, and perhaps with an average temperature somewhat below that prevalent in the same region today or in Illinoian time. By contrast, the aquatic gastropods in Crete-Loveland deposits indicate an environment of ephemeral ponds or silt-laden streams. Stated in another way, it can be said that environmental conditions in western Kansas in late Kansan times, as judged by the assemblage of aquatic mollusks in Sappa silts, were similar to those prevailing today in central Michigan; while on the same basis, the Crete-Loveland fauna indicates that the environment in Kansas in late Illinoian time was not remarkably different from that found in the same area today, although admittedly somewhat better supplied with moisture, and perhaps slightly cooler. By the same sort of analogy, ecological conditions in central and western Kansas in Illinoian times, rather than resembling modern climates at higher latitudes, compare better with modern ecological conditions in the same latitude, but at a position farther east toward the more humid Missouri-Mississippi Valley region. Thus, I judge that ecological conditions in central and western Kansas at time of deposition of the Crete-Loveland sediments, were not unlike those existing today in central Missouri.

PEORIAN MOLLUSCAN FAUNAS

The stratigraphic position of the Peoria silt member of the Sanborn formation has been reviewed and discussed at length by FRYE & A. B. LEONARD (1951) and A. B. LEONARD (1951). It was shown by these authors that the massive, upland silt, called Peoria silt in Kansas classification, is Wisconsinan in age, although not representing all of Wisconsinan time. Deposition of the Peoria loess began after the climax of the Sangamonian interglacial substage and was concluded by the Bradyan interglacial substage, which has been shown to be placed in time between the Tazewellian and Careyan substages. The Brady buried soil is developed in upper portions of the Peoria silt. The faunal assemblage herein reported is almost exclusively from upland situations; faunas from a few ponds on the old loess surface have been included, but terraces of equivalent age purposely have been excluded.

The faunal assemblage from the Peoria loess, in Kansas, as now known, consists of 28 species, most

of which are terrestrial gastropods. A few pulmonate gastropods of aquatic habit also occur in the assemblage. The fossil mollusks from the Peoria silt at nearly a hundred localities are shown in tabular form in Figure 5.

ZONATION OF THE PEORIA LOESS

In the summer of 1948, investigation of the molluscan fossils in the Peoria loess in Kansas was inaugurated, with view to determining whether climatic changes concomitant with the presumed several glacial substages represented in this loess were reflected in facies changes in the faunal assemblages, and if so, whether or not faunal zones in the Peoria could be interpreted in terms of subdivisions of the loess within the glaciated region. Toward this end, cubic foot samples of the loess were taken at short vertical intervals in suitable exposures where the loess could be shown to lie above the Sangamon (Loveland) soil, and the shells were recovered by washing the silt through screens. As these studies progressed, it became apparent that the Peoria loess in Kansas could be divided conveniently into zones on the evidence obtained from these quantitative paleontological studies.

These studies, which have continued to the present time, allow recognition within the body of the Peoria loess of three well-characterized zones. A basal zone of variable thickness is devoid of fossil mollusks, but in part it is correlative with the *Citellus* zone of Nebraska classification (CONDRA, REED, & GORDON, 1947, p. 30), from which a fossil vertebrate fauna has been obtained. Above this basal zone in suitable exposures are a lower and an upper molluscan faunal zone, each containing a distinctive assemblage of species, and related by a transitional zone containing elements of both faunal assemblages. Each of these aspects of zonation in the Peoria loess in the State is readily recognized in the field.

BASAL ZONE

The basal zone of the Peoria varies from a few inches to 6 feet or more in thickness, and it consists of loess which has been more or less oxidized and to varying degrees leached of its free carbonates. The greatest degree of leaching occurs in the base of the zone, directly above the Loveland soil A-horizon, where often no effervescence can be obtained by the use of dilute acid and where the silt is usually oxidized to a pinkish-red color. These effects disappear by imperceptible degrees upward into calcareous, unoxidized, and fossiliferous loess. The upper and lower limits of the zone are not critically definable, for frequently it is impossible to delineate the top of the Loveland soil A-horizon, because materials in the base of the basal zone (superimposed upon the Loveland soil) may be stained more or less with organic matter, as well as leached and oxidized, and because, at its upper limits, etched and weathered fragments of gastropod shells may appear slightly below the lower fossiliferous zone. Viewed objectively, it is clear that the basal zone silts at first were deposited so slowly that the loess weathered greatly as it fell, and that depositional rates gradually accelerated with time until finally rate of deposition completely outstripped rate of weathering of the basal zone silts, and relatively unaltered loess accumulated thereafter for a considerable time. It may be inferred, though not easily proved, that gastropods were present at the time this silt was deposited and that the shells subsequently were destroyed by weathering processes; there is no reason to believe that these animals could not have lived under conditions suitable for the vertebrates which left their bones in this basal zone loess.

LOWER MOLLUSCAN ZONE (IOWAN)

The lower molluscan faunal assemblage contains 14 species of gastropods of small size and terrestrial habit, two of which are restricted to this zone, while the remaining species appear also in the upper faunal assemblage. The presence of these restricted species, however, and the universal absence of no less than 14 species known to occur only in the upper faunal assemblage, makes the lower assemblage distinctive enough for practical purposes and readily discernible on outcrops of the loess.

Among lower zone species, *Vallonia gracilicosta, Pupilla muscorum, P. blandi, Vertigo gouldi paradoxa,* and *Helicodiscus singleyanus* are extinct in Kansas; most remaining forms are restricted to favorable situations in the eastern part of the State. A few, including *Succinea avara, Hawaiia minuscula,* and *Deroceras laeve,* are living over most of the area considered in this report, especially in locally favorable habitats.

The most widespread species in the lower faunal zone are *Vallonia gracilicosta, Succinea avara, Pupilla muscorum, P. blandi,* and *Hawaiia minuscula,* which occur at almost every locality reported, including those in southwestern Kansas, where conditions, then as now, seem to have been generally unfavorable for terrestrial gastropods. Since three of these species are now extinct in the State, the lower fauna is readily recognizable in southwestern Kansas where the loess is thin. In this region, fully half of this zone commonly is included in the soil profile, and any shells once present in this part have been removed by weathering. One species, *Lymnaea parva,* sometimes considered an aquatic animal, although actually littoral in habit, locally occurs in the loess at sites of ponds on former loess surfaces.

Above the basal zone, the lower faunal zone assemblage increases progressively upward, both in numbers of species and individual shells. For example, at locality no. 18 (Decatur county) (Pl. 1, Fig. 5) the lower 5 feet of a 25-foot exposure of

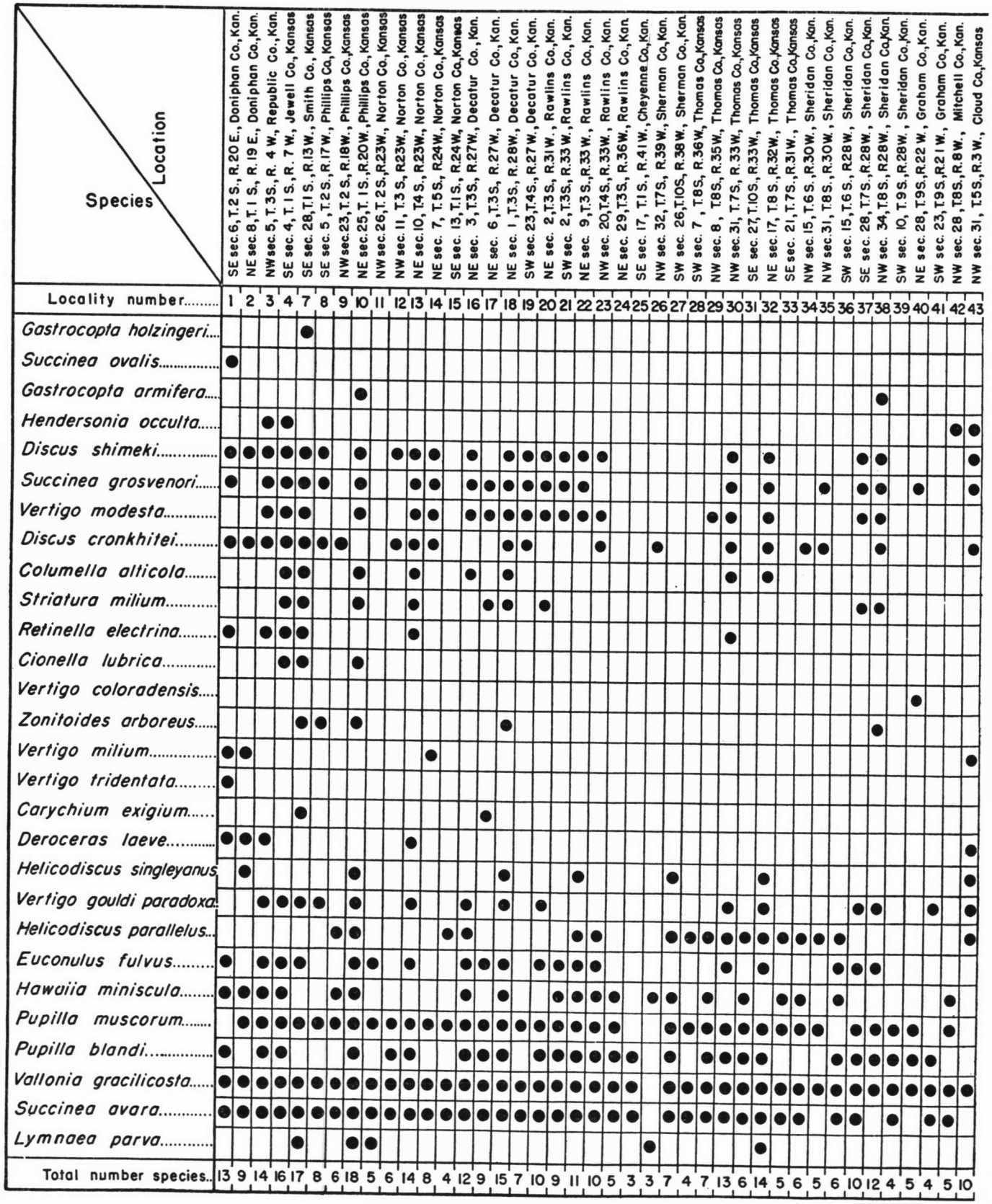
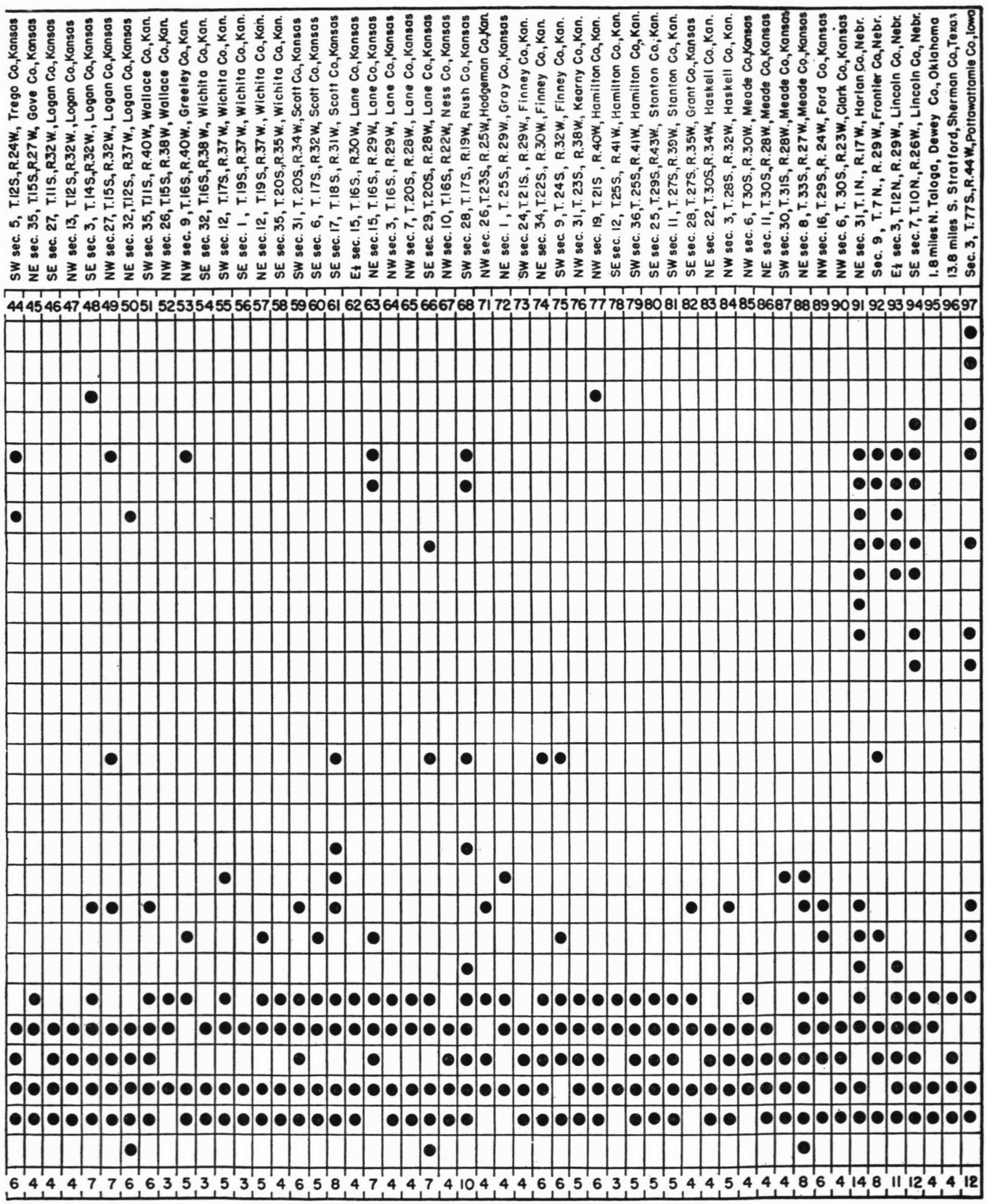


FIGURE 5.—Molluscan species



of the Peoria loess in Kansas.

Peoria loess contains no shells (basal zone); 7 feet above the base, 139 shells grouped in four species were recovered from a cubic foot of silt; while 13 feet above the base, a cubic foot of loess yielded 753 shells assigned to 6 species. At this same locality, the transitional zone assemblage consists of 11 species and a total of 5,079 shells per cubic foot; the upper faunal zone comprises 14 species, and a population of 1,578 shells per cubic foot of loess.

TRANSITIONAL ZONE

Between the lower and upper faunal zones in the Peoria loess, a transitional faunal zone occurs, which bears elements of both the lower and upper faunal assemblages. Not regarded here as a significant subdivision in the Peoria loess, this zone nevertheless serves to verify the absence of any important change in rate of deposition during accumulation of the main body of the Peoria, and confirms the absence of any demonstrable lithologic unconformity in the complex silt. Conditions seem to have been favorable for mollusks during this interval, and it is possible that depositional rates slowed somewhat, if one may judge from the fact that the highest population density occurs in the transitional zone. It is equally obvious that depositional rates did not become sufficiently retarded at any time to allow weathering processes to remove much free carbonate from the loess nor to destroy any appreciable proportion of the shells.

Discus cronkhitei, followed by *D. shimeki,* are the first of the upper zone species to appear in the transitional zone, usually in association with *Succinea avara,* which is otherwise restricted to the lower faunal. *S. grosvenori* and *S. ovalis* appear higher in the transitional zone, generally after disappearance of *S. avara.* Other upper zone species which may appear in the transitional zone are less widespread, and their order of appearance seems to reflect local conditions rather than general climatic change.

UPPER MOLLUSCAN ZONE (TAZEWELLIAN)

The upper faunal assemblage (Pl. 1, Fig. 5) comprises 26 species, including 14 which do not occur in the lower assemblage. Four species, *Columella alticola, Striatura milium, Vertigo coloradensis,* and *Discus shimeki,* do not now live within the Great Plains region, nor are these species known from any Pleistocene or older horizon in Kansas. *Discus cronkhitei, Pupilla muscorum, P. blandi, Hendersonia occulta, Vallonia gracilicosta, Vertigo modesta,* and *Helicodiscus singleyanus* are likewise extinct in the Great Plains region, but they are known from earlier Pleistocene horizons in Kansas (Fig. 3), the last only from the lower Peoria faunal zone. In all, 11 of the 26 species in the upper assemblage are extinct in the State, making this zone easily recognizable in the field. The remaining species are not generally present over the area under consideration, being restricted to local situations, particularly in northeastern Kansas. As pointed out above, conditions were more favorable than now for terrestrial mollusks during the time of deposition of the loess containing the transitional and upper assemblages, for shells are present in great numbers, commonly exceeding 5,000 shells per cubic foot. The greater variety of species, compared to the living fauna, and the presumed ecological requirements of the species now extinct in the State confirm this conclusion.

ECOLOGICAL IMPLICATIONS OF THE FAUNAL ZONES

It is not possible to interpret the ecological conditions associated with Peorian deposition with a high degree of accuracy, because ecological factors which limit the distribution of terrestrial gastropods are inadequately known. Specifically, it is not known why the Peorian species now extinct in Kansas and in the Great Plains generally no longer live there. It is clear, however, that ecological conditions during Peorian deposition were relatively favorable to terrestrial gastropods, since the fossil faunas, even in the lower faunal zone, were more varied than are the Recent faunas in the same areas. It is likely that the population density was also greater, judging from the large numbers of shells recoverable from a cubic unit of loess, but rate of deposition is a factor which cannot be determined by any known means, so the actual numbers of shells per cubic foot may be somewhat misleading.

A reasonable amount of rainfall and a floral cover at least as dense as that prevailing now may be inferred to have existed over the area in Kansas involved in Peorian deposition, since terrestrial gastropods are active and can reproduce only during intervals when the soil and overlying organic matter are moist. Two reasons may be advanced for judging that temperatures were slightly lower than at present: (1) The Peorian species now extinct in Kansas presently live at higher latitudes or altitudes, and (2) *Bulimulus dealbatus,* a gastropod of southern affinities which has reached the northern border of Kansas in Recent times, is absent in the Peoria loess.

While Peorian species extinct in the state now live at higher latitudes than when they populated Kansas, the exact limiting factors which brought about their extinction are not known. Extreme minimal temperatures on the Great Plains are not greatly at variance from those prevailing in the regions now occupied by these locally extinct species, nor is there any appreciable difference in average annual rainfall. A possible limiting factor, which may account for extinction of the Peorian species in Kansas is occurrence on the Great Plains of cyclical intervals of extremely high temperatures and severe aridity. In the face of little direct evidence, it may be inferred that these phenomena are re-

sponsible for extinction of the species so abundantly present in the Peoria loess. It seems reasonable to assume that the presence of continental and Rocky Mountain ice sheets would exert a stabilizing influence on temperatures and rainfall, without necessarily lowering average annual temperatures in the Great Plains to any appreciable degree.

It is clear that ecological conditions changed during the whole interval in which the Peoria loess in Kansas was being deposited, since the upper zone fauna contains so many new elements, and because it seems that population density increased, perhaps a great deal. In view of these facts, attempts were made to find suitable loess faunas in the glaciated region where the loess could be associated positively with a single glacial interval. I am indebted to Dr. H. B. WILLMAN, of the Illinois Geological Survey, for the opportunity of collecting a molluscan fauna from undoubted Tazewell loess, in an exposure near Crêve Coeur, Illinois. This faunal assemblage is an almost exact correlative of the upper zone fauna of the Peoria loess in Kansas.

CORRELATION OF THE PEORIA LOESS

It now seems possible to limit the age of the Peoria loess in Kansas, and to correlate the zones within it with units recognized elsewhere. In Nebraska, Iowa, and Illinois, as well as in Kansas, the Peoria complex almost invariably has at its base a somewhat weathered zone, which generally grades into calcareous, fossiliferous loess, but which at a few places in Nebraska, Iowa, and Illinois is terminated above by a weakly weathered zone. To my knowledge, the most westerly exposure which shows a weak profile at the top of the "Farmdale" zone in the Peoria loess, occurs at Bignell Hill, in the loess hills south of the Platte River, a few miles southeast of the city of North Platte, Nebraska. This exposure is about on the same longitude as western Decatur County, in western Kansas. This loess, wherever I have seen it over these four States is most greatly leached and oxidized at its base and has a pinkish color. It has been called the Farmdale loess by LEIGHTON & WILLMAN (1949, p. 48), from the Farm Creek section in central Illinois. Here, but nowhere else to my knowledge, this unit has considerable organic matter in its upper few inches, indicating a slowing of the rate of deposition.

The best explanation for the Farmdale interval seems to lie in assuming that the Iowa ice advanced and receded slightly, producing outwash valley trains from which silts were air-borne. These were deposited slowly as the Peoria basal zone loess. The Iowa ice then readvanced to its final stage, destroying evidence of its earlier stand. Whatever the true explanation may be for the basal zone loess, its identical stratigraphic position, nature and degree of weathering, and similarity in lithology over a wide region, conclusively indicates that the basal zone of the Peoria complex of Kansas is equivalent to the Farmdale loess of Illinois.

The existence of a slightly weathered zone, the presence of organic matter in the Farmdale loess at the Farm Creek exposure, and the lack of these features in Kansas are susceptible to more than one explanation. The Peoria loess in Kansas clearly has two general sources; the loess in eastern Kansas is derived from Missouri River valley trains, whereas that in central, western, and southern Kansas originated from such valleys as the Platte, Arickaree, and Republican (SWINEFORD & FRYE, 1951) during late Pleistocene glacial episodes under influence of Rocky Mountain glaciation rather than continental ice sheets. The lowermost part of the Peoria loess in northeastern Kansas generally is not exposed, but in the few available outcrops, the basal zone is found to lack indication of a weathered zone in its top. This may be due to purely local conditions of drainage or erosion, though no erosional unconformities have been identified. The loess in the remainder of the State accumulated in an area of presumed lesser rainfall, which might account for the lack of a weathered zone; but a more likely explanation is that Rocky Mountain glaciers of Iowan age did not have the inferred initial advance and minor retreat of the continental ice sheet generally synchronous with it.

Since the upper faunal zone assemblage is identical with that found in known Tazewell loess, and since the lower and upper faunal zones are separated neither by a faunal hiatus nor by a lithologic break (unconformity), even without a molluscan fauna from restricted Iowa loess, it seems appropriate to correlate Peoria loess in Kansas containing the lower faunal assemblage with the Iowa loess (Iowan and post-Iowan in age) of Iowa and Illinois, and Peoria loess in Kansas containing the upper faunal assemblage with Tazewell loess (Tazewellian and post-Tazewellian in age) of Illinois.

AREAL EXTENT OF IOWA AND TAZEWELL LOESSES IN KANSAS

The lower faunal zone of the Peoria loess has been traced from northeastern Kansas through central, western, and southwestern Kansas, and is present at all localities shown in Figure 2. The same faunal assemblage has been obtained in northwestern Oklahoma in Dewey County, in northern Texas in Sherman County, and in Frontier and Lincoln Counties, Nebraska. It is judged that the loess in which this faunal assemblage occurs is largely retreatal Iowan in age.

The upper faunal assemblage is much more restricted in its distribution in Kansas but is known from southern and central Nebraska, western Iowa, and central Illinois. This assemblage can be traced across the northern border of Kansas, except for Cheyenne County in the extreme western part of

the State, and southward to Rush, Lane, Gove, and Logan Counties (localities 68, 64, 49, 50). It is concluded from the faunal evidence that these places mark the approximate southern border of the greatest extent of Tazewell ice influence upon loess deposition in Kansas. However, since the Peoria loess of southwestern Kansas is thin, nearly half its thickness being involved in the Recent soil profile, it is possible that loess blown from Tazewell valley trains was carried even farther south, evidence having been lost by weathering of the shells.

BIGNELLIAN MOLLUSCAN FAUNAS

The youngest loess deposit recognizable in Kansas is the Bignell silt member of the Sanborn formation. The Bignell loess forms a discontinuous mantle above the Brady soil. It occurs generally in local depressions with thickness seldom exceeding 5 or 6 feet. Near the Missouri River in northeastern Kansas, however, the Bignell loess attains thickness of more than 40 feet.

The exact age of the Bignell loess in Kansas cannot be determined at present. It is not subdivisible by petrographic means, and generally the molluscan fauna associated with it is too sparse to permit faunal zonation. At the Iowa Point section, described by FRYE & A. B. LEONARD (1949), the Bignell loess shows evidence of zonation, both in its chemical properties and in its contained fauna, but no conclusions are drawn from this single exposure. All that can be said with certainty as to age of the Bignell loess is that it is post-Bradyan, and thus it presumably includes the span of Careyan-Mankatoan time. It seems safe to assume that the greater portion of the Bignell loess accumulated rather early in this interval, however, since the modern soil profile developed within it is moderately matured.

The molluscan fauna associated with the Bignell loess is shown in tabular form in Figure 6. Everywhere the Bignellian molluscan fauna resembles the local modern fauna. Thus, in timbered loess hills of northeastern Kansas near the Missouri River, the fauna is predominantly characteristic of the assemblage of species found today in local forested areas, while in the Great Plains, the fauna of the Bignell loess is identical with the sparse fauna of minute gastropods which occurs there locally at the present time.

The final stage in progressive desiccation of the Great Plains, which seems to have begun after Yarmouthian times and to have culminated in the semiarid climate of modern time, took place during or after the Bradyan interglacial interval. The great populations of *Discus, Pupilla,* and *Vertigo,* together with less widespread populations of *Hendersonia occulta, Columella alticola, Striatura milium, Euconulus fulvus,* and many other species, completely vanished from the Great Plains at the close of Tazewellian time. As I interpret conditions from the fossil molluscan faunas, the vegetative cover became reduced at this time, the climate became somewhat warmer, and it is probable that a biologically severe climate, characterized by extremes of summer aridity and high temperatures, followed by cold dry winters, began in post-Bradyan times. Only a few species of gastropods can endure the rigors of the Great Plains environment at the present time; and because mollusks of the Bignell loess are identical with the present fauna, conclusion is inevitable that the environment of Bignell loess deposition was very like present conditions in the Great Plains.

Species	Locality Number							
	1	2	11	19	21	50	60	93
Anguispira alternata	●							
Gastrocopta armifera	●	●						
Hendersonia occulta	●							
Stenotrema monodon aliciae	●	●						
Succinea grosvenori	●							
Succinea ovalis	●	●						
Triodopsis multilineata	●	●						
Vallonia gracilicosta	●							
Vallonia pulchella		●	●		●		●	●
Hawaiia miniscula	●	●	●	●		●		●
Helicodiscus parallelus	●	●		●		●		
Physa anatina						●		
Succinea avara			●		●	●	●	
Total number species	10	7	3	2	2	4	2	2

FIGURE 6.—Molluscan species of the Bignell loess in Kansas.

SUMMARY AND CONCLUSIONS

A distinctive and readily recognizable molluscan fauna of 27 species is associated with Crete-Loveland (Illinoian) deposits in Kansas. This fauna is intermediate in character between that found in the Sappa silts (late Kansan or early Yarmouthian) and that associated with the Peoria loess (early Wisconsinan). The Crete-Loveland fauna is characterized by absence of the large populations of branchiate and pulmonate aquatic gastropods which are adapted to life in permanent, clear, water, and which flourished at the time of deposition of the Sappa silts. Also absent from the Crete-Loveland faunas are a few characteristic species, such as *Columella alticola* and *Striatura milium*, which occur commonly in the Tazewellian zone of the Peoria loess.

The molluscan fauna of the Peoria silt, comprising 28 species, is also well characterized and distinctive. It is notable for the predominance of such genera as *Discus, Pupilla, Columella, Striatura, Euconulus, Hendersonia,* and others, which now are absent from the Great Plains. It has been shown that the molluscan faunal assemblages of the Peoria loess occur in stratigraphic zones. Recognized zones in the Peoria loess include, (1) a basal zone, generally somewhat weathered, lacking mollusks, which is judged to be the time equivalent of Farmdale loess deposition in Illinois, (2) a lower faunal zone, characterized by a small assemblage of minute species, which is judged to be the time equivalent of the Iowa loess elsewhere, and (3) an upper faunal zone, characterized by a large and varied assemblage of species, which is judged to be the time equivalent of the Tazewell loess.

The Bignellian molluscan fauna comprises 13 species, only 5 of which have general distribution in the Great Plains; the remainder have been observed in the Bignell loess only at exposures near the Missouri River. The Bignellian fauna everywhere reflects the local, modern molluscan fauna. The occurrence of *Hendersonia occulta* in the Iowa Point section of northeast Kansas is the only known exception to this rule.

DESCRIPTION OF SPECIES

The species which occur in the Illinoian and Wisconsinan deposits treated in this paper are listed below in alphabetical order. Since many of them have been discussed previously in a study of the Yarmouthian faunas of the Great Plains (LEONARD, 1950), many details have been omitted. Each species is described, however, with notation of its stratigraphic range, and each is illustrated.

References to literature are limited to (1) the original description, (2) a standard modern work in which the present name combination is used, and (3) my paper on the Yarmouthian molluscan fauna, if the species occurs in the Sappa silts.

Anguispira alternata (SAY), terrestrial gastropod

Plate 2, figure *L*

Helix alternata SAY, 1816, Nicholson's British Encyclopedia, 1st Am. ed., article Conchology, species no. 4, pl. 1, fig. 2 (no pagination).

Anguispira alternata, PILSBRY, 1948, Land Mollusca North America, vol. 2, p. 568, fig. 305, Philadelphia.

Type locality.—"Middle States" as given by SAY; the vicinity of Philadelphia has been selected by PILSBRY (1948, p. 570) as a specific type locality.

Description.—Shell helicoid, a little over 5 whorls; widely umbilicate; peristome simple. In life, the color is tan, marked with reddish-brown spots, which often remain faintly discernible in the fossil shells. The diameter of mature shells is about 20 mm.

Stratigraphic range.—This species has been observed as a fossil in Kansas only in the Bignell loess near the Missouri River. It occurs, however, in Peoria loess in the type section of the Loveland loess at the town of Loveland, in Pottawattamie County, Iowa.

Remarks.—This is a typical woodland species, which lives under the bark of dead trees, or in leaf mold. It is living in Kansas as far west as the Flint Hills.

Carychium exiguum (SAY), terrestrial gastropod

Plate 4, figure *G*

Pupa exigua SAY, 1822, Jour. Acad. Nat. Sci. Philadelphia, vol. 2, p. 375.

Carychium exiguum, PILSBRY, 1948, Land Mollusca North America, vol. 2, p. 1052, figs. 561-562, Philadelphia.

Type locality.—Harrigate (Philadelphia), Pennsylvania.

Description.—Shell minute, rimate, oblong-conical; about 4.5 whorls; aperture over one-third total length of shell; peristome reflexed and thickened; an entering lamella visible on inner margin of peristome; length of shell, about 1.7 mm.

Stratigraphic range.—This species occurs in Crete-Loveland sediments along with *Carychium perexiguum*, which becomes extinct in Illinoian times. *C. exiguum* occurs also in Peoria silts and is living at the present time in humid situations.

Remarks.—*Carychium exiguum* can be distinguished from *C. perexiguum* with difficulty; the former is somewhat more slender, but principal differences of the two species are in the internal lamellae. To determine them requires dissection of the tiny shell and interpretation by an experienced student.

Carychium perexiguum BAKER, terrestrial gastropod

Plate 4, figure *D*

Carychium perexiguum BAKER, 1938, Nautilus, vol. 51, p. 128; ———, LEONARD, 1950, Univ. Kansas Paleo. Contr., Mollusca, art. 3, p. 22, pl. 1, fig. D.

Description.—Shell minute, elongate-conical; 5 whorls, convex; aperture slightly more than one-third total length of the shell, peristome reflected and thickened, bearing a conspicuous callosity just above middle of the outer lip; lamella on columella, appearing tubercular from external view, but actually ascending as a spiral fold around the axis; length, 1.8-2.0 mm.

Stratigraphic range. — *Carychium perexiguum* ranges from Blanco to Crete-Loveland deposits, where it seems to become extinct.

Cionella lubrica (MÜLLER), terrestrial gastropod

Plate 5, figure *S;* Figure 7

Helix lubricus MÜLLER, 1774, Vermium Terrestrium et Fluvium, vol. 2, p. 104.

Cionella lubrica, PILSBRY, 1948, Land Mollusca North America, vol. 2, p. 1047, fig. 560, a, b, Philadelphia; ———, LEONARD, 1950, Univ. Kansas Paleo. Contrib., Mollusca, art. 3, p. 25, pl. 5, fig. G.

Description.—Shell elongate spiral; spire tapering gradually to an obtuse apex; 5.5 to 6 whorls, moderately convex, suture not sharply incised; surface polished; aperture subvertical, ovate, simple; outer lip thickened, arcuate, inner lip straight; length of shell, 5 to 6.5 mm. *Cionella lubrica* is easily recognized by its size, shape, and polished surface, which is unlike any other gastropod shell in this region.

Stratigraphic range.—Yarmouth to Recent; not found in Crete-Loveland sediments, but locally abundant in Peoria loess (Tazewellian zone).

Remarks.—The species lives in woodlands or woodland borders. Where it is found in Peoria loess, the sediments are invariably near stream courses, which suggests that western streams had a better growth of trees along them in early Wisconsinan times than now. Its present distribution is shown on Figure 7.

Columella alticola (INGERSOLL), terrestrial gastropod

Plate 5, figure *I;* Figure 13

Pupilla alticola INGERSOLL, 1875, Bull. U. S. Geol. and Geogr. Serv. Terr., vol. 1, p. 128.

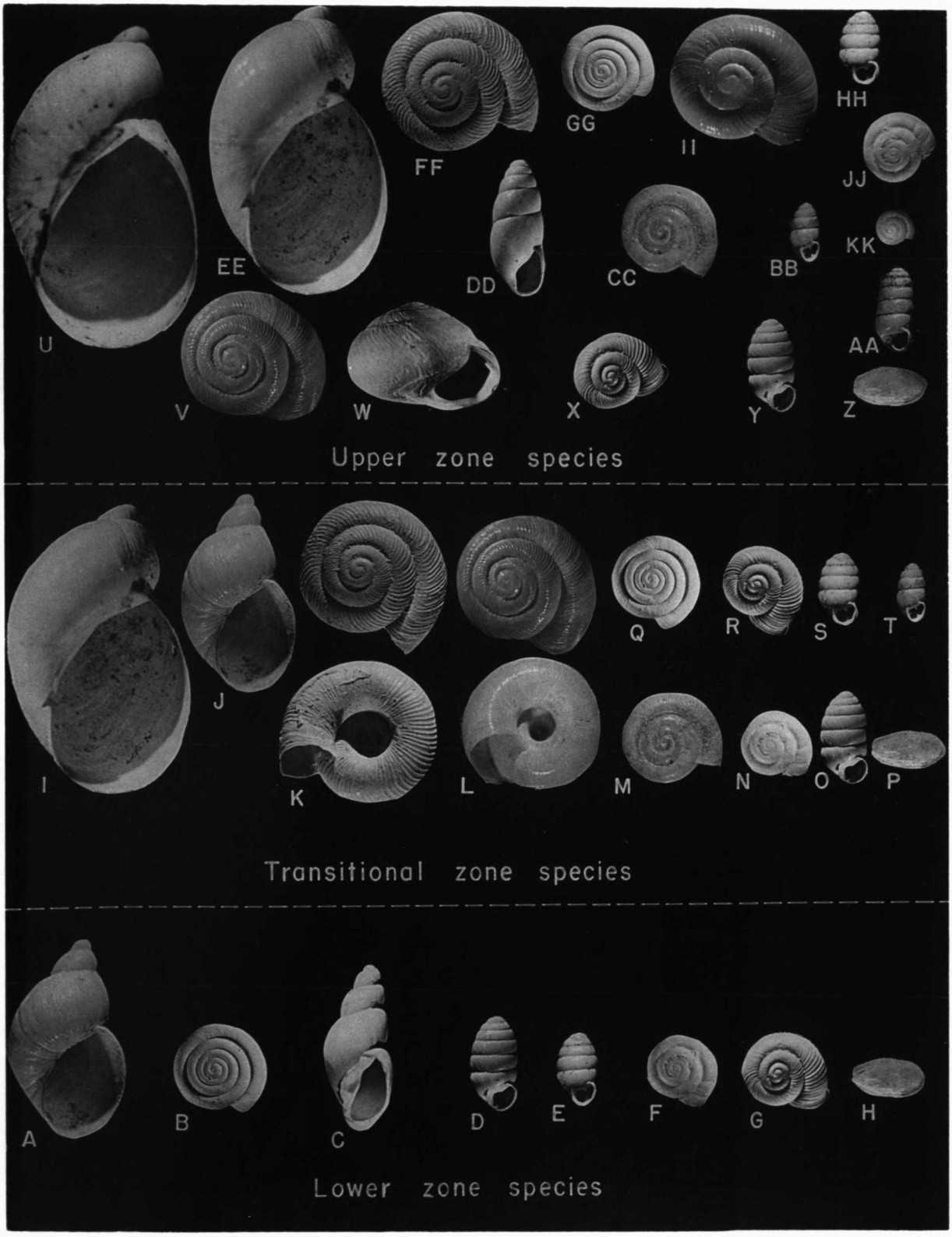
Columella alticola, PILSBRY, 1948, Land Mollusca North America, vol. 2, p. 1003, fig. 536, Philadelphia.

Type locality.—Cunningham Gulch, Colorado, altitude 8,000-9,000 feet.

Description.—Shell cylindrical, perforate; 6 to 7 whorls; suture deeply impressed; aperture small, oblique, peristome simple, slightly thickened; length of shell, 2.5 to 2.8 mm.

EXPLANATION OF PLATE 1

Typical faunal assemblages in zones of the Peoria loess in Kansas. All figures approximately 4 times natural size.



Leonard—Pleistocene Mollusca

Stratigraphic range.—Peoria loess (Tazewellian zone). A few records of living *Columella alticola* are known, most of which are shown on Figure 13. Each of these localities is at elevation of 7,500 feet or more.

Deroceras laeve (MÜLLER), terrestrial gastropod

Plate 4, figure *J*

Limax laevis MÜLLER, 1774, Vermium Terrestrium et Fluvium, vol. 2, p. 2.

Deroceras laeve, PILSBRY, 1948, Land Mollusca North America, vol. 2, p. 539, fig. 289, Philadelphia.

Type locality.—Denmark.

Description.—Shell an ovoid, flattened, internal plate, bearing concentric growth lines: left margin more convex than right; nucleus not quite terminal on left side at posterior end; length about 4 mm.

Stratigraphic range.—Crete-Loveland, Peoria, to Recent.

Remarks.—These small, flattened plates are the internal shells of a small slug, which in life is about an inch long. The animals inhabit organic debris in moist situations. Whether or not the American species is identical with the European one described by MÜLLER has long been a subject of discussion, but there seems little doubt that fossils from the Tazewellian zone of the Peoria loess are identical with shells of living North American slugs. A larger, heavier shell of a slug (*Deroceras aenigma*), which may be ancestral to the living species, occurs in Sappa silts.

Discus cronkhitei (NEWCOMB), terrestrial gastropod

Plate 4, figures *N-O;* Figure 8

Helix cronkhitei NEWCOMB, 1865, Proc. California Acad. Sci., vol. 3, p. 180.

Discus cronkhitei, PILSBRY, 1948, Land Mollusca North America, vol. 2, p. 600, fig. 328, Philadelphia; ———, LEONARD, 1950, Univ. Kansas Paleo. Contrib., Mollusca, art. 3, p. 35, pl. 4, fig. E.

Description.—Shell depressed, low conoid; 4 whorls; umbilicus open, exhibiting all whorls, rib-striate above and below; aperture rounded, peristome simple, thin; diameter of shell, 5 to 6.5 mm.

Stratigraphic range.—Sappa, Crete-Loveland, Peoria to Recent. In the Peoria loess (Tazewellian zone), *D. cronkhitei* is largely replaced by *D. shimeki.*

Remarks.—The range of living *D. cronkhitei* is shown on Figure 8.

Discus shimeki (PILSBRY), terrestrial gastropod

Plate 5, figures *R, T;* Figure 9

Zonitoides shimekii PILSBRY, 1890, Nautilus, vol. 4, p. 3.

Discus shimeki, PILSBRY, 1948, Land Mollusca North America, vol. 2, p. 617, fig. 335a, Philadelphia.

Type locality.—Peoria loess, Iowa City, Iowa.

Description.—Shell low, conical; 4.2 to 4.5 whorls, robust; periphery rounded, base narrowly umbilicate; sculpture of prominent ribs above, which disappear on base of whorls; aperture subcircular; peristome simple; diameter, about 6 mm.

Stratigraphic range.—Peoria loess (Tazewellian zone) to Recent.

Remarks.—Discus shimeki is readily distinguished from *D. cronkhitei,* which it otherwise resembles, by lack of rib-striations on the base of whorls. *D. shimeki* is abundant in the Tazewellian zone of the Peoria loess, where it occurs with *D. cronkhitei* at many localities. Both are reliable indices to the Tazewellian zone fauna. The range of living *D. shimeki* is shown in Figure 9.

Euconulus fulvus (MÜLLER), terrestrial gastropod

Plate 4, figure *I*

Helix fulva MÜLLER, 1774, Vermium Terrestrium et Fluvium, vol. 2, p. 56.

Euconulus fulvus, PILSBRY, 1946, Land Mollusca North America, vol. 2, p. 235, fig. 117, Philadelphia; ———, LEONARD, 1950, Univ. Kansas Paleo. Contrib., Mollusca, art. 3, p. 37, pl. 5, fig. F.

Description.—Shell thin, small, with about 4.5 whorls; surface polished; conical in profile view, body whorl much enlarged; peristome thin, sharp; aperture lunate; diameter of shell, about 3.2 mm.

Stratigraphic range.—Sappa silts, Peoria loess to Recent.

Remarks.—Euconulus fulvus occurs in the Tazewellian zone of the Peoria loess, but nowhere in large numbers. It is a species which lives only where good cover of organic debris is available.

Gastrocopta armifera (SAY), terrestrial gastropod

Plate 5, figure *L*

Pupa armifera SAY, 1821, Jour. Acad. Nat. Sci. Philadelphia, vol. 2, p. 162.

Gastrocopta armifera, PILSBRY, 1948, Land Mollusca North America, vol. 2, p. 874, fig. 472, Philadelphia; ———, LEONARD, 1950, Univ. Kansas Paleo. Contrib., Mollusca, art. 3, p. 29, pl. 6, fig. P.

Description.—Shell elongate oval, rimate, summit obtusely conical; 6.5 whorls, moderately convex, surface marked with oblique striae; aperture irregularly rounded; peristome thin, expanded, connected across parietal wall by a callus; denticles 6, including a fused angulo-parietal, a conspicuous subhorizontal columellar, a low inconspicuous basal, and two palatal folds.

Stratigraphic range.—Sappa silts, Crete-Loveland sands and silts, Peoria loess, Bignell loess to Recent.

Remarks.—This is the largest pupillid gastropod in the faunas reported here. It can be confused only with *Gastrocopta proarmifera,* which became extinct in Yarmouthian times.

Gastrocopta holzingeri (STERKI), terrestrial gastropod

Plate 5, figure *B*

Pupa holzingeri STERKI, 1889, Nautilus, vol. 3, p. 37.

Gastrocopta holzingeri, PILSBRY, 1948, Land Mollusca North America, vol. 2, p. 883, fig. 474-475, Philadelphia; ———, LEONARD, 1950, Univ. Kansas Paleo. Contrib., Mollusca, art. 3, p. 31, pl. 6, fig. A.

Description.—Shell small, not exceeding 2 mm. in height, ovoid, rimate; 4.5 to 5 whorls, regularly increasing in size; body whorl less than half the height of shell; aperture rounded, exceeding one-half height of body whorl; denticles 7, including a fused angulo-parietal, which converges inward in the form of an inverted image of the letter Y, 4 palatal folds on a heavy callus; a horizontal columellar lamella which turns downward within; peristome narrowly reflected, terminations approaching; height of shell, 1.6 to 1.9 mm.

Stratigraphic range.—Sappa silts, Crete-Loveland sands and silts, and Peoria loess; its occurrence in the latter is rare in the Tazewellian zone.

Remarks.—This species may be recognized by its small size, large number of denticles, and the peculiar shape of the fused angulo-parietal denticle.

Gastrocopta tappaniana (C. B. ADAMS), terrestrial gastropod

Plate 5, figure *E*

Pupa tappaniana C. B. ADAMS, 1842, (in) Thompson's History of Vermont, p. 158.

Gastrocopta tappaniana, PILSBRY, 1948, Land Mollusca North America, vol. 2, p. 889, fig. 477, Philadelphia; ———, LEONARD, 1950, Univ. Kansas Paleo. Contrib., Mollusca, art. 3, p. 31, pl. 6, fig. D.

Description.—Shell small, elongate conical, spire blunt; 4.5 to 5 whorls, obese, suture deeply impressed; sculpture of fine, transverse growth lines; a heavy callus on body whorl paralleling the subrectangular aperture, separated from the rim of the peristome by a narrow groove; denticles 6 to 9, including a low, tubercular infraparietal (rarely present), a completely fused, high, angulo-parietal on the center of the parietal wall, and as many as 6 equally immersed palatal folds on a heavy callus; peristome reflected, thin, margin acute; height of shell, 1.5 to 2.5 mm.

Stratigraphic range.—Sappa silts, Crete-Loveland sands and silts, to Recent. It has not been found in the Peoria loess.

Gyraulus similaris BAKER, aquatic pulmonate gastropod

Plate 3, figures *D-E*

Gyraulus similaris BAKER, 1917, Am. Mus. Nat. Hist., Bull., vol. 41, p. 529; ———, LEONARD, 1950, Univ. Kansas Paleo. Contrib., Mollusca, art. 3, p. 19, pl. 3, fig. J.

Description.—Shell small for the genus, discoidal, spiral surface slightly concave; 4 whorls, regularly increasing in size, rounded above and below; body whorl deflected downward toward aperture; sculpture of fine growth striae; lip simple, not thickened within; diameter about 6 mm.

Stratigraphic range.—Sappa silts, Crete-Loveland sands and silts, to Recent. It occurs now as small relict populations in the Rocky Mountains in lakes at elevations of 8,000 feet or more.

Remarks.—This species is rather common in Sappa silts and occurs but rarely in the Crete-Loveland sediments, where it seems to have become extinct in the Great Plains.

Hawaiia minuscula (BINNEY), terrestrial gastropod

Plate 4, figures *E-F*

Helix minuscula BINNEY, 1840, Boston Jour. Nat. Hist., vol. 3, p. 435, pl. 22, fig. 4.

Hawaiia minuscula, PILSBRY, 1946, Land Mollusca North America, vol. 2, p. 420, figs. 228-229, Philadelphia; ———, LEONARD, 1950, Univ. Kansas Paleo. Contrib., Mollusca, art. 3, p. 36, pl. 5, fig. A.

Description.—Shell minute, umbilicate, spire low, convex; 4 whorls, strongly convex, slowly enlarging in size toward the aperture; nuclear whorls smooth, remaining irregularly and finely striate above, almost smooth below; aperture nearly round; peristome thin, simple; diameter of shell, 2.2 to 2.8 mm.

Stratigraphic range.—Laverne formation (lower Pliocene) to Recent.

Remarks.—This species seems so remarkably adapted to a wide range of habitats and environmental situations that its presence in a faunal assemblage means little. It lives in the Great Plains today, often under quite adverse circumstances.

EXPLANATION OF PLATE 2

All figures 4 times natural size.

FIGURE	PAGE
A,C—Helisoma trivolvis lentum (SAY)	21
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G—Succinea avara SAY	23
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Leonard—Pleistocene Mollusca

Helicodiscus parallelus (SAY), terrestrial gastropod

Plate 5, figures *P-Q*

Planorbis arallelus SAY, 1821, Jour. Acad. Nat. Sci. Philadelphia, vol. 2, p. 164 (corrected to *parallelus* in index).

Helicodiscus parallelus PILSBRY, 1948, Land Mollusca North America, vol. 2, p. 625, fig. 339, Philadelphia; ———, LEONARD, 1950, Univ. Kansas Paleo. Contrib., Mollusca, art. 3, p. 34, pl. 4, fig. A.

Description.—Shell small, coin-shaped, the upper surface plane to slightly convex, umbilicus broad and shallow; 4 to 4.5 whorls, the first 1.5 faintly striated, the remainder conspicuously marked with numerous spiral raised lines, narrower than the interval between them; diameter, a little over 3 mm.

Stratigraphic range.—Sappa silts, Crete-Loveland, Peoria loess, Bignell loess to Recent. This species is widely distributed on the Great Plains at the present time.

Remarks.—*Helicodiscus parallelus* is easily recognized from its small size, discoid form, and presence of spiral striations on the whorls. The last whorl bears two pairs of small conical denticles within; these are not visible from without.

Helicodiscus singleyanus (PILSBRY), terrestrial gastropod

Plate 4, figure *H;* Figure 10

Zonites singleyanus PILSBRY, 1890, Proc. Acad. Nat. Sci. Philadelphia, p. 84 (for 1889).

Helicodiscus singleyanus PILSBRY, 1948, Land Mollusca North America, vol. 2, p. 636, fig. 346, Philadelphia.

Type locality.—New Braunfels, Texas.

Description. — Shell minute, depressed, thin, widely umbilicate; spire low, slightly convex; surface glossy to waxy in appearance, growth striae weak to absent; aperture lunate; peristome simple; 3.5 to 4 whorls; diameter of shell, about 2.4 mm.

Stratigraphic range.—Crete-Loveland sands and silts, Peoria loess (Tazewellian zone) to Recent.

Remarks.—*Helicodiscus singleyanus* is easily confused with *Hawaiia minuscula,* from which it can be distinguished by its weak-to-obsolete growth lines, waxy surface, and presence of faint, closely crowded spiral lines, seen only with high magnification.

The present distribution of living *H. singleyanus* is shown on Figure 10.

Helisoma antrosa (CONRAD), aquatic pulmonate gastropod

Plate 2, figures *H-I*

Planorbis antrosus CONRAD, 1834, American Jour. Sci., vol. 25, p. 343.

Helisoma antrosa, BAKER, 1928, Wisconsin Geol. Nat. Hist. Surv., Bull. 70, pt. 1, p. 317, pl. 19, figs. 8-15; ———, LEONARD, 1950, Univ. Kansas Paleo. Contrib., Mollusca, art. 3, p. 16, pl. 3, fig. B.

Description.—Shell ultra-dextral, discoidal; body whorl angulate above and below; sculpture of strong, transverse striae; umbilicus deep, infundibuliform, exhibiting all the whorls; spire depressed; aperture with somewhat bell-shaped enlargement; lip thin, simple; diameter of shell, 6 to 10 mm.

Stratigraphic range.—Lower Pliocene to Recent. *Helisoma antrosa* is common in Blanco deposits, Sappa silts, and rarely in Crete-Loveland sediments. It is not now found alive on the Great Plains.

Helisoma trivolvis lentum (SAY), aquatic pulmonate gastropod

Plate 2, figures *A, C*

Planorbis trivolvis SAY, 1819, Nicholson's British Encyclopedia, 1st American ed., art. "Conchology", pl. 2, fig. 2 (no pagination).

Helisoma trivolvis BAKER, 1928, Wisconsin Geol. Nat. Hist. Surv., Bull. 70, pt. 1, p. 330, pl. 20, figs. 1-13, 22, 33; ———, LEONARD, 1950, Univ. Kansas Paleo. Contrib., Mollusca, art. 3, p. 16, pl. 3, fig. A.

Description.—Shell ultra-sinistral, plano-spiral; 4 whorls; coarse sculpture of raised, obliquely transverse, raised lines; suture deeply impressed; spire generally depressed, plane; aperture broadly lunate; expanded below; lip simple, thin, acute, sometimes thickened a little within; diameter of shell, 15 to 25 mm.

Stratigraphic range.—Sappa silts to Recent. Common in pond deposits in Crete-Loveland sediments; the species is common in stagnant waters on the Great Plains today.

Hendersonia occulta (SAY), terrestrial gastropod

Plate 3, figure *C;* Figure 15

Helicina occulta SAY, 1831, Transylvania Jour. Med., vol. 4, p. 528.

Hendersonia occulta PILSBRY, 1948, Land Mollusca North America, vol. 2, p. 1087, fig. 581, Philadelphia; ———, LEONARD, 1950, Univ. Kansas Paleo. Contrib., Mollusca, art. 3, p. 38, pl. 4, fig. F.

Description.—Shell somewhat depressed, but with conical spire, rather solid, with about 5 nearly flat whorls; surface dull, bearing fine, transverse growth striae; periphery more or less keeled; aperture oblique, subtriangular to semicircular; peristome narrowly expanded, strongly thickened, edge rounded; diameter variable, 5 to 7.25 mm.

Stratigraphic range.—Sappa silts, Peoria loess, Bignell loess. This species is the only instance known to me of a locally extinct species occurring in the Bignell silt. It does so at exposures near the Missouri River in northeastern Kansas. *Hendersonia occulta* occurs in the Tazewellian zone of the Peoria loess as far west as Republic County, Kansas.

Lymnaea parva LEA, aquatic pulmonate gastropod

Plate 4, figure *L*

Lymnaea parva LEA, 1841, Proc. American Philos. Soc., vol. 2, p. 33; ———, LEONARD, 1950, Univ. Kansas Paleo. Contrib., Mollusca, art. 3, p. 15, pl. 2, fig. D.

Description.—Shell small for the genus, elongate-conical; more or less turreted; 5 to 5.5 whorls; spire

elevated, acute; suture deeply impressed; aperture elliptical; outer lip of peristome thin, simple, inner lip thickened and reflected over columella; umbilical chink open; axis straight, not twisted; total height, 5 to 9 mm.

Stratigraphic range.—Blanco deposits to Recent. *Lymnaea parva,* which is capable of living in or near ephemeral pools, occurs in old, buried deposits of ponds in the Peoria loess.

Physa anatina LEA, aquatic pulmonate gastropod

Plate 2, figure *B*

Physa anatina LEA, 1866, Jour. Acad. Nat. Sci. Philadelphia, vol. 6, p. 171, pl. 24, fig. 94; ———, LEONARD, 1950, Univ. Kansas Paleo. Contrib., Mollusca, art. 3, p. 21, pl. 2, fig. F.

Description.—Shell obliquely conical, sinistral, 4 whorls, convex, suture deeply impressed; spire conical, short; aperture elongate, more than half the length of the shell; outer lip of peristome thin, simple, inner lip thickened, reflected upon body whorl; height of shell, 12 to 15 mm.

Stratigraphic range.—Laverne formation (lower Pliocene) to Recent. *Physa anatina* is less common than *P. elliptica* in Blanco and Sappa deposits. It is rather common in late Pleistocene sediments and occurs in stagnant waters on the Great Plains today.

Pupilla blandi MORSE, terrestrial gastropod

Plate 5, figure *K*; Figure 11

Pupilla blandi MORSE, 1865, Ann. Lyceum Nat. Hist. New York, vol. 8, p. 5, fig. 8; ———, PILSBRY, 1948, Land Mollusca North America, vol. 2, p. 929, fig. 502: 1-5, Philadelphia; ———, LEONARD, 1950, Univ. Kansas Paleo. Contrib., Mollusca, art. 3, p. 28, pl. 6, fig. L.

Description.—Shell ovately cylindrical, 6 whorls, suture deeply impressed; apex obtuse; last whorl descending at base; aperture expanded; a heavy callus behind peristome, separated from it by a groove; aperture nearly circular, bearing three blunt denticles of about equal size, one on the parietal margin, one on the columellar margin, one at the base of the aperture; height of shell, about 3 mm.

Stratigraphic range.—Sappa silts, Crete-Loveland sands and silts, Iowan and Tazewellian zones of Peoria loess, to Recent. This species, together with *P. muscorum, Succinea avara* and *S. grosvenori,* is extremely useful in recognition of the Peoria loess.

Remarks.—The present distribution of living *P. blandi* is shown in Figure 11.

Pupilla muscorum (LINNÉ), terrestrial gastropod

Plate 5, figure *J;* Figure 12

Turbo muscorum LINNÉ, 1758, Systema Naturae, 10th ed., p. 767, Upsala.

Pupilla muscorum PILSBRY, 1948, Land Mollusca North America, vol. 2, p. 933, fig. 503:12-16, Philadelphia; ———, LEONARD, 1950, Univ. Kansas Paleo. Contrib., Mollusca, art. 3, p. 28, pl. 6, fig. N.

Description.—Shell large for pupillid snail, cylindrically ovate, 6 to 7 whorls, convex but not inflated; rimate; nuclear whorls granulate, remaining finely striate; a prominent crest parallels the peristome behind, separated from it by a groove; aperture truncately oval, slightly oblique, typically edentulous, although a poorly developed parietal tooth may be present; peristome sharply everted, margins acute, terminations approaching; height of shell, 2.9 to 3.9 mm.

Stratigraphic range.—Sappa silts, Crete-Loveland sands and silts, Iowan and Tazewellian zones of the Peoria loess, to Recent.

Remarks. — The distribution of living *Pupilla muscorum* in North America is shown in Figure 12.

Pupoides albilabris (C. B. ADAMS), terrestrial gastropod

Plate 5, figure *M*

P(upa) albilabris C. B. ADAMS, 1841, "Ward's letter", Amer. Jour. Sci., vol. 40, p. 271 (new name for *Cyclostoma marginata* SAY).

Pupoides albilabris PILSBRY, 1948, Land Mollusca North America, vol. 2, p. 921, fig. 499: 1-7, Philadelphia; ———, LEONARD, 1950, Univ. Kansas Paleo. Contrib., Mollusca, art. 3, p. 29, pl. 6, fig. Q.

Description.—Shell elongate, tapering from last whorl to obtuse apex, rimate, 4.5 to 6.5 whorls; nuclear whorls granular, remaining obliquely and finely striate; aperture roundly ovate, oblique; peristome broadly reflected, heavily thickened within; height of shell, 3.7 to 5.6 mm.

Stratigraphic range.—Laverne formation (lower Pliocene) to Recent. It has been found at every stratigraphic horizon within the Pleistocene in the Great Plains, except the Bignell loess.

Retinella electrina (GOULD), terrestrial gastropod

Plate 4, figures *K, M*

Helix electrina GOULD, 1841, Invertebrata of Massachusetts, p. 183, fig. 111.

Retinella electrina PILSBRY, 1946, Land Mollusca North America, vol. 2, p. 256, fig. 126, Philadelphia; ———, LEONARD, 1950, Univ. Kansas Paleo. Contrib., Mollusca, art. 3, p. 36, pl. 5, fig. H.

EXPLANATION OF PLATE 3

All figures 10 times natural size.

Leonard—Pleistocene Mollusca

Description.—Shell depressed, deeply umbilicate; sculpture of numerous radial grooves, which are wanting on first whorl and on base of shell; surface polished and shining; 3.5 to a little more than 4 whorls; aperture ovoid-lunate; peristome, simple, thin; diameter of shell, 4.5 to 5.5 mm.

Stratigraphic range.—Blanco silts to Recent. It occurs sparingly in the Sappa silts, Crete-Loveland sediments, and Tazewellian zone of the Peoria loess.

Remarks. — *Retinella electrina* may be distinguished from *Zonitoides arboreus,* which it resembles, by the polished surface and grooved lines; the sculpture of *Z. arboreus* consists of raised lines.

Sphaerium solidulum (PRIME), pelecypod

Plate 2, figure *E*

Cyclas solidula PRIME, 1851, Proc. Boston Soc. Nat. Hist., p. 158.

Sphaerium solidulum BAKER, Wisconsin Geol. Nat. Hist. Survey, Bull. 70, pt. 2, p. 323, pl. 97, figs. 1-3; pl. 98, figs. 26-28.

Type locality.—Ohio.

Description.—Shell elongate-ovate; the umbones slightly anterior to the center of the shell; surface heavily sculptured with concentric, raised lines; shell moderately inflated, 10 to 13 mm. in length.

Stratigraphic range.—Not known. *Sphaerium solidulum* occurs in the Sappa silts and in the Crete-Loveland sediments; it is abundant locally in Crete sands and gravels.

Remarks.—The systematic relationships of small clams comprising the family Sphaeriidae are poorly known. Persons who wish identifications of these shells are advised to send them to Mr. H. B. HERRINGTON, Kent, Ontario, Canada, who understands them better than any other conchologist in North America.

Stenotrema monodon aliciae (PILSBRY), terrestrial gastropod

Plate 3, figures *F-G*

Helix monodon var. *aliciae* PILSBRY, 1893, Manual Conchology, vol. 8, p. 152, Philadelphia.

Stenotrema monodon aliciae PILSBRY, 1940, Land Mollusca North America, vol. 1, p. 679, fig. 421c, Philadelphia.

Type locality.—Louisiana.

Description.—Shell almost imperforate, subglobose, spire convex, 5.5 to 6 whorls; base of shell strongly convex; aperture semi-lunate; peristome reflected, thickened; a single denticle, extending roughly parallel to outer lip; diameter of shell, about 7.5 mm.

Stratigraphic range. — Unknown. It has been found in the Bignell loess near the Missouri River in northeastern Kansas and is widely distributed as a living species in the Missouri and Mississippi River valleys.

Striatura milium (MORSE), terrestrial gastropod

Plate 4, figure *A;* Figure 11

Helix milium MORSE, 1859, Proc. Boston Soc. Nat. Hist., vol. 7, p. 28.

Striatura milium PILSBRY, 1946, Land Mollusca North America, vol. 2, p. 495, fig. 272, Philadelphia.

Type locality.—Maine.

Description.—Shell minute, scarcely 1.5 mm. in diameter, broadly umbilicate, spire low, convex; a little over 3 whorls; first 1.5 whorls smooth, remaining whorls finely costulate, decussated by closer spiral lines, aperture subcircular, peristome simple.

Stratigraphic range.—Unknown. *Striatura milium* occurs as a fossil in the Tazewellian zone of the Peoria loess.

Remarks.—This minute shell may be overlooked easily because of its small size. The present range of the living species is shown in Figure 11.

Strobilops sparsicosta BAKER, terrestrial gastropod

Plate 5, figures *N-O*

Strobilops sparsicosta BAKER, 1938, Nautilus, vol. 51, p. 127; ———, LEONARD, 1950, Univ. Kansas Paleo. Contrib., Mollusca, art. 3, p. 34, pl. 5, fig. C.

Description.—Shell obtusely conical, resembling an old-fashioned beehive; 5.5 whorls convex, the first 1.5 smooth, the remainder embellished with distinct riblets, rather widely spaced; body whorl angulate at base; base nearly smooth; aperture expanded, peristome thickened and bearing a heavy callus; two lamellae on parietal wall within aperture.

A complex series of lamellae is present within the shell; dissection is required to expose them.

Stratigraphic range.—Blanco deposits, Sappa silts, to Crete-Loveland sands and silts, where the species becomes extinct.

Remarks.—At base of the Loveland loess at the type locality in western Iowa, an unidentifiable species of *Strobilops* was recovered with other species of gastropods. This may be *S. sparsicosta,* but the examples at hand are too fragmentary to determine the identity of the shell.

Succinea avara SAY, terrestrial gastropod

Plate 2, figure *G*

Succinea avara SAY, 1824, Appendix, Keating's Narrative, Major Long's Second Expedition, vol. 2, p. 260, pl. 15, fig. 6; ———, PILSBRY, 1948, Land Mollusca North America, vol. 2, p. 837, fig. 455, Philadelphia; ———, LEONARD, 1950, Univ. Kansas Paleo. Contrib., Mollusca, art. 3, p. 23, pl. 4, fig. G.

Description.—Shell slender, length nearly twice the diameter; 3 or a little more whorls; surface irregularly wrinkled, with coarse growth lines on the body whorl; suture deeply impressed; aperture ovate, up to two-thirds the length of the shell; lip thin, simple, shell thin, fragile, length of shell, 7 to 11 mm.

Stratigraphic range.—Sappa silts to Recent. It has not been seen in Crete-Loveland sediments, and in the Peoria loess it occurs regularly in the Iowan faunal zone, rarely in the base of the Tazewellian zone.

Succinea grosvenori LEA, terrestrial gastropod

Plate 2, figure *J*

Succinea grosvenori LEA, 1864, Proc. Acad. Nat. Sci. Philadelphia, p. 109, April 12; ———, PILSBRY, 1948, Land Mollusca North America, vol. 2, p. 819, fig. 444, 452, i, j, Philadelphia; ———, LEONARD, 1950, Univ. Kansas Paleo. Contrib., Mollusca, art. 3, p. 24, pl. 4, fig. I.

Description.—Shell asymmetrically conical, 3 to 3.5 whorls, spiral whorls short, body whorl large, all strongly convex; suture deeply incised; aperture ovoid, peristome simple, thin; surface sculpture of irregular growth striae; length of shell, 12 to 15 mm.

Stratigraphic range.—Blanco to Recent. *Succinea grosvenori* is present in the Sappa silts, Crete-Loveland sediments, and the Tazewellian zone of the Peoria loess; it is invariably absent from the Iowan zone of the Peoria loess.

Remarks.—*Succinea grosvenori* may be distinguished from *S. avara* by its larger size and more obese whorls. It is smaller than *S. ovalis,* and the aperture is less elongately ovoid.

Succinea ovalis SAY, terrestrial gastropod

Plate 2, figure *K;* Figure 14

Succinea ovalis SAY, 1817, Jour. Acad. Nat. Sci. Philadelphia, vol. 1, p. 15; ———, PILSBRY, 1948, Land Mollusca North America, vol. 2, p. 801, fig. 430-433, Philadelphia; ———, LEONARD, 1950, Univ. Kansas Paleo. Contrib., Mollusca, art. 3, p. 24, pl. 4, fig. J.

Description.—Shell elongately oval, inflated; 3 to 3.5 whorls; spire small, body whorl large, inflated, convex throughout; aperture elongately ovate, about three-fourths the length of the shell; sculpture of fine growth striae; total length of shell, about 16 mm.

Stratigraphic range.—Unknown. *Succinea ovalis* occurs rarely in the Tazewellian zone of the Peoria loess as far west as central Kansas; it occurs in the Bignell loess near the Missouri River in northeastern Kansas. There it is living among shrubs on the higher levels of floodplain of the Missouri River.

Remarks.—The distribution of living *Succinea ovalis* is shown in Figure 14.

Triodopsis multilineata (SAY), terrestrial gastropod

Plate 2, figures *D, F*

Helix multilineata SAY, 1821, Jour. Acad. Nat. Sci. Philadelphia, vol. 2, p. 150; ———, PILSBRY, 1940, Land Mollusca North America, vol. 1, p. 847, fig. 493, Philadelphia.

Type locality.—Illinois and Missouri.

Description. — Shell imperforate, globose, although somewhat depressed; surface finely striate; spire moderately elevated; peristome narrowly reflected, slightly thickened; parietal callus typically without denticle, although a weakly developed, low, oblique tooth sometimes appears; diameter of shell, about 22 mm.

Stratigraphic range.—Unknown. I have found it in the area of this study only in the Bignell loess near the Missouri River in northeastern Kansas, where it lives today among the shrubs on the higher parts of the floodplain of the Missouri River.

Vallonia gracilicosta REINHARDT, terrestrial gastropod

Plate 4, figures *B-C;* Figure 13

Vallonia gracilicosta REINHARDT, 1883, Sitszungs-Ber. Ges. Naturforsch., Freunde Berlin, p. 42; ———, PILSBRY, 1948, Land Mollusca North America, vol. 2, p. 1028, fig. 549a, Philadelphia; ———, LEONARD, 1950, Univ. Kansas Paleo. Contrib., Mollusca, art. 3, p. 33, pl. 5, fig. D.

Description.—Shell minute, almost flat spiral, 2.5 whorls, convex, suture deeply impressed; surface sculpture of riblets obliquely transverse to whorls; last whorls enlarging rapidly toward aperture, descending; peristome strongly reflected, thickened, the terminations approaching, connected by a callus; diameter of shell, about 2.5 mm.

Stratigraphic range.—Blanco deposits to Recent. It has been found at every stratigraphic horizon in the Pleistocene deposits in Kansas except the Bignell loess, where it is replaced by *Vallonia parvula,* the living representative of the genus in the State.

Remarks. — The distribution of living *Vallonia gracilicosta* is shown on Figure 13.

EXPLANATION OF PLATE 4

All figures 10 times natural size.

Leonard—Pleistocene Mollusca

Vallonia pulchella (MÜLLER), terrestrial gastropod

Helix pulchella MÜLLER, 1774, Vermium Terrestrium et Fluvium, vol. 2, p. 3, Denmark.

Vallonia pulchella PILSBRY, 1948, Land Mollusca North America, vol. 2, p. 1023, fig. 545a, Philadelphia; ———, LEONARD, 1950, Univ. Kansas Paleo. Contrib., Mollusca, art. 3, p. 33, pl. 5, fig. B.

Description.—Shell small, not over 2.5 mm. in diameter, depressed spiral, with 3.5 whorls, suture deeply impressed; umbilicus, narrow, deep; surface silky in texture, lacking riblets or costae; aperture oblique, peristome abruptly expanded, thickened within.

The lack of costae serves to distinguish *Vallonia pulchella* from *V. gracilicosta* at a glance.

Stratigraphic range.—Sappa silts to Recent. It is a rare species in Pleistocene deposits in Kansas; I have not found it in the Peoria loess, where *Vallonia gracilicosta* is so abundant.

Vertigo gouldi coloradensis (COCKERELL), terrestrial gastropod

Plate 5, figure *C;* Figure 14

Pupa coloradensis COCKERELL, 1891, British Naturalist, p. 100.

Vertigo gouldi coloradensis PILSBRY, 1948, Land Mollusca North America, vol. 2, p. 974, fig. 518, Philadelphia.

Type locality.—Near Swift Creek, Custer County, Colorado.

Description.—Shell small, thin, oblong-oval, apex blunt; 4 whorls, aperture pyriform; peristome thickened; denticles typically 4, one on parietal wall, one at base of columella, and two on palatal wall; length of shell, about 1.75 mm.

Stratigraphic range.—Unknown. *Vertigo coloradensis* occurs rarely in the Tazewellian zone of the Peoria loess. The distribution of the living species is shown on Figure 14.

Vertigo gouldi paradoxa STERKI, terrestrial gastropod

Plate 5, figure *D;* Figure 13

Vertigo gouldi paradoxa STERKI, 1900, (in Nylander) Nautilus, vol. 13, p. 103; ———, PILSBRY, 1948, Land Mollusca North America, vol. 2, p. 972, fig. 518:5, 8, 520, Philadelphia.

Type locality. — Woodland, Aroostook County, Maine.

Description. — Shell small, about 1.75 mm. in length, heavier than that of *Vertigo gouldi coloradensis,* more obese; denticles typically 4, one on parietal wall, one at base of columella, two on palatal wall, the lower much more deeply immersed than the upper; peristome rounded; outer lip almost straight.

Stratigraphic range.—Unknown. It occurs in the Peoria loess in the Tazewellian faunal zone.

Remarks. — The distribution of living *Vertigo gouldi paradoxa* is shown in Figure 13.

Vertigo milium (GOULD), terrestrial gastropod

Plate 5, figure A

Pupa milium GOULD, 1840, Boston Jour. Nat. Hist., vol. 3, p. 402.

Vertigo milium PILSBRY, 1948, Land Mollusca North America, vol. 2, p. 944, fig. 509, Philadelphia; ———, LEONARD, 1950, Univ. Kansas Paleo. Contrib., Mollusca, art. 3, p. 26, pl. 6, fig. C.

Description.—Shell small, rarely over 1.5 mm. in length, ovate to ovoid-cylindrical in shape, rimate; 4.5 to 5 whorls, convex, finely striate; body whorl large, more than half the height of shell, contracted at base, and expanded at aperture; aperture ovate, strongly biarcuate, expanded; peristome slightly everted, lip thin, simple; denticles 6: an elongate, lamelliform parietal; a smaller, more deeply immersed angular lamella; an elongate upper palatal fold; a more deeply immersed lower palatal fold, curved strongly toward the columella; a low, somewhat elongated basalar, and a short, crescentic columellar lamella.

Stratigraphic range.—Blanco deposits to Recent. This species occurs most commonly in the Peoria silt, where it is numerous at many places in the Tazewellian faunal zone.

Vertigo modesta (SAY), terrestrial gastropod

Plate 5, figure *H;* Figure 15

Pupa modesta SAY, 1824, Keating's Narrative, Major Long's Second Expedition Northwest Terr., Appendix, p. 259, pl. 15, fig. 5.

Vertigo modesta PILSBRY, 1948, Land Mollusca North America, vol. 2, p. 982, figs. 527-528, Philadelphia; ———, LEONARD, 1950, Univ. Kansas Paleo. Contrib., Mollusca, art. 3, p. 27, pl. 6, fig. H.

Description.—Shell ovately conical, summit convex, rimate; 4.5 to 5 whorls, convex; nuclear whorls finely granular, remaining whorls coarsely and irregularly striate; body whorl more than half the height of shell; aperture ovate, outer peristome scarcely indented; denticles 3 or 4, including a low, slightly elongate parietal lamella, a low, tubercular upper palatal fold, a larger and somewhat more elongate lower palatal fold, and a low, short, horizontally disposed columellar fold; palatal folds not on a callus; peristome not everted, margins slightly rounded; height of shell, about 2 mm. or a little more.

Stratigraphic range.—Sappa silts to Recent. *Vertigo modesta* is common in the Tazewellian faunal zone of the Peoria loess.

Remarks.—The distribution of living *Vertigo modesta* is shown in Figure 15.

Vertigo ovata SAY, terrestrial gastropod

Plate 5, figure *G*

Vertigo ovata SAY, 1822, Jour. Acad. Nat. Sci. Philadelphia, vol. 2, p. 375; ———, PILSBRY, 1948, Land Mollusca North America, vol. 2, p. 952, fig. 513: 1-3, 4, 7, Philadelphia; ———, LEONARD, 1950, Univ. Kansas Paleo. Contrib., Mollusca, art. 3, p. 26, pl. 6, fig. F.

Description.—Shell ovoid, spire obtusely conical; 5 whorls, increasing rapidly in size; a strong crest behind the peristome; outer lip of peristome strongly indented; 9 denticles; 3 parietal lamellae; 5 folds on a palatal callus, and an elongate columellar lamella; peristome narrowly reflected, lip thin, acute; height of shell, 1.8 to 2.7 mm.

Stratigraphic range.—Laverne formation (lower Pliocene) to Recent. It is known from the Crete-Loveland sediments but is absent from the Peoria loess. A few relict colonies live in Kansas in extremely moist situations.

Vertigo tridentata WOLF, terrestrial gastropod

Plate 5, figure *F;* Figure 10

Vertigo tridentata WOLF, 1870, Amer. Jour. Conchology, vol. 5, p. 198, fig. 1; ———, PILSBRY, 1948, Land Mollusca North America, vol. 2, p. 965, fig. 518: 1-3, Philadelphia; ———, LEONARD, 1950, Univ. Kansas Paleo. Contrib., Mollusca, art. 3, p. 26, pl. 6, fig. G.

Description. — Shell ovate to tapering oblong, about 5 whorls, the last flattened externally over the lower palatal fold and bearing a crest behind the subarcuate peristome; lamellae 3 or 4, including a high, short parietal lamella, a blunt, downwardly directed columellar lamella, and a strongly developed lower palatal fold; upper palatal fold weak or wanting; angular and basal fold lacking; height of shell, 1.85 to 2.2 mm.

Stratigraphic range.—Sappa silts to Recent, including Crete-Loveland sediments and Tazewellian zone of Peoria loess, but everywhere rare.

Remarks.—The distribution of living *Vertigo tridentata* is shown on Figure 10.

Zonitoides arboreus (SAY), terrestrial gastropod

Plate 3, figures *A-B*

Helix arboreus SAY, Nicholson's British Encyclopedia, 1st American Ed., vol. 2, article "Conchology", pl. 4 (no pagination).

Zonitoides arboreus, PILSBRY, 1946, Land Mollusca North America, vol. 2, p. 480, fig. 261-262, Philadelphia; ———, LEONARD, 1950, Univ. Kansas Paleo. Contrib., Mollusca, art. 3, p. 37, pl. 4, fig. B.

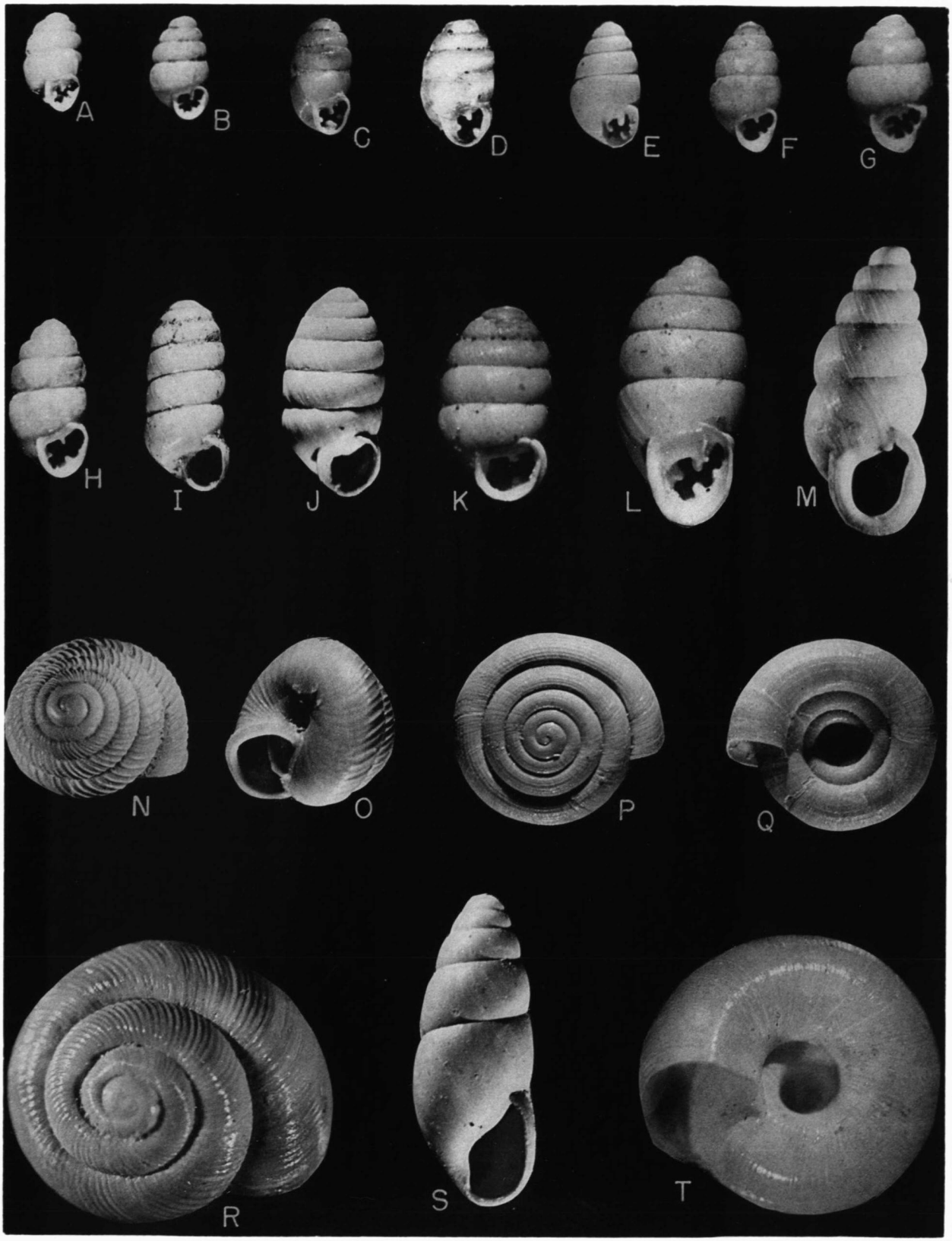
Description.—Shell depressed spiral, openly umbilicate, with 4.5 convex, regularly enlarging whorls; sculpture of transverse growth striae; aperture lunate, lip of peristome thin, simple; diameter of shell, about 5.5 mm.

Stratigraphic range.—Sappa silts to Recent, but rare in the Peoria loess, where it occurs in the Tazewellian faunal zone.

Remarks. — Zonitoides arboreus can be distinguished from *Retinella electrina,* which it somewhat resembles, by the presence of the raised growth striae; the shell of *R. electrina* is smooth and polished and bears transverse grooves.

EXPLANATION OF PLATE 5

All figures 10 times natural size.



Leonard—Pleistocene Mollusca

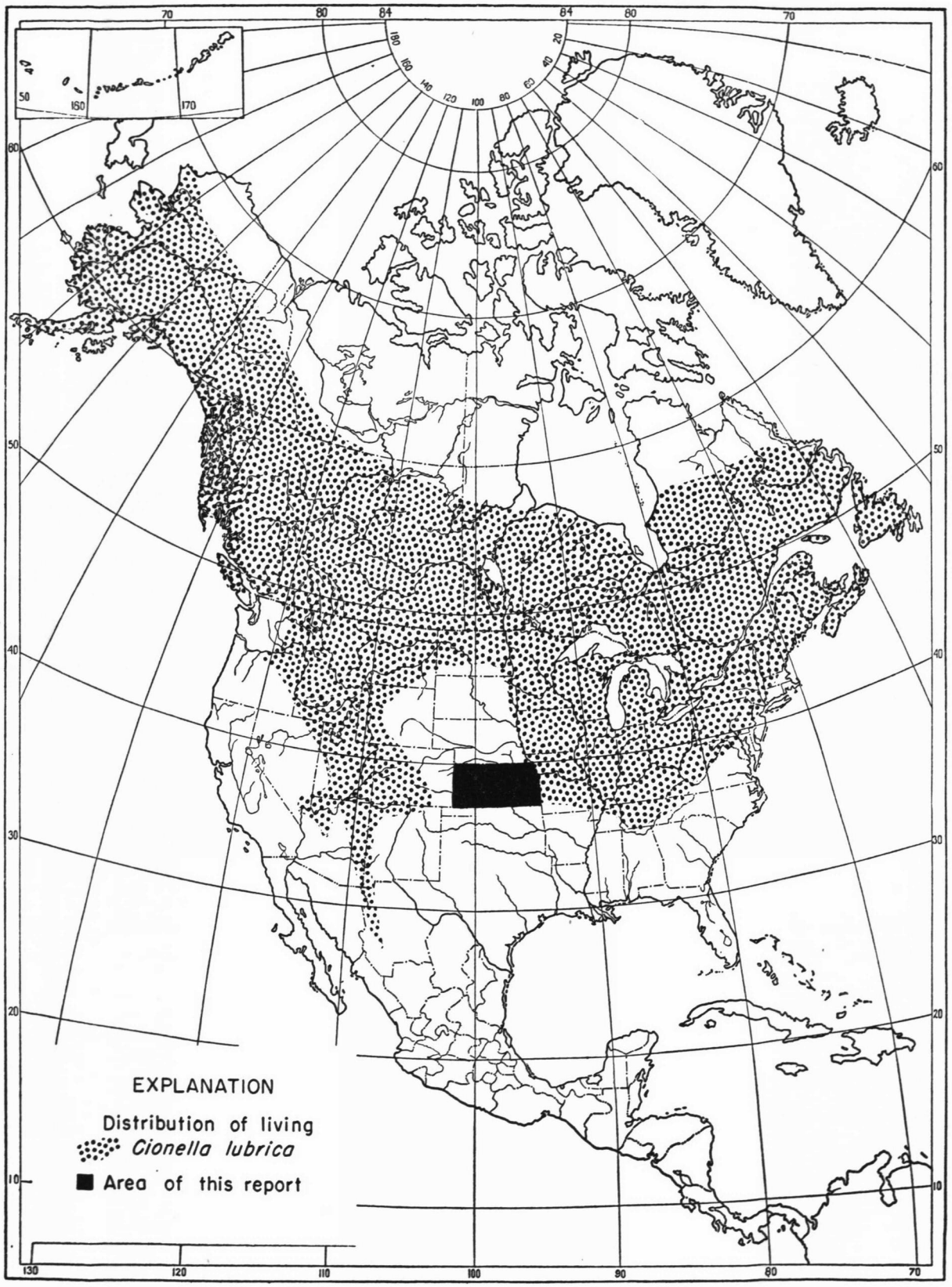


FIGURE 7.—Distribution of living *Cionella lubrica* in relation to the area of this report.

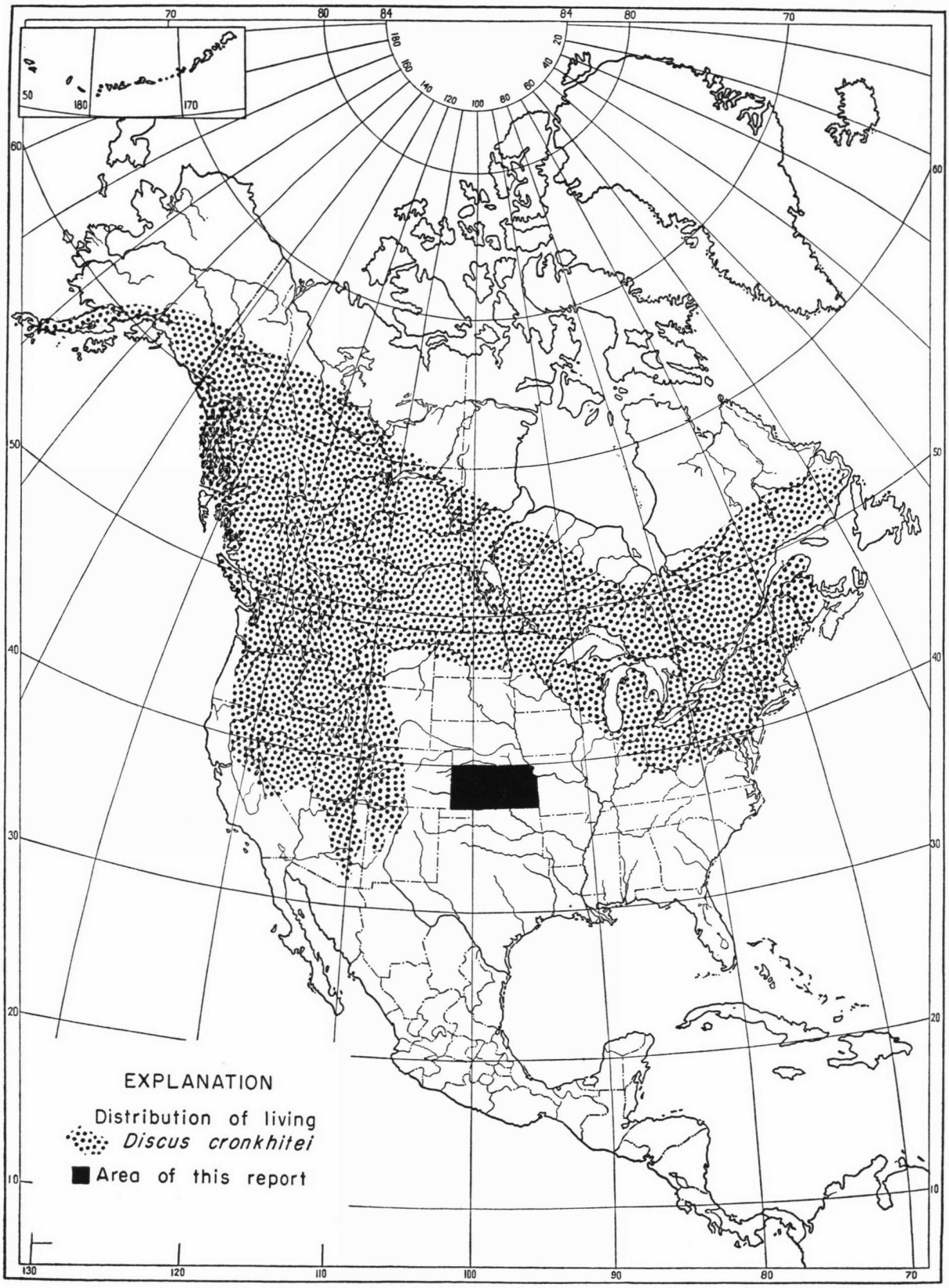


FIGURE 8.—Distribution of living *Discus cronkhitei* in relation to the area of this report.

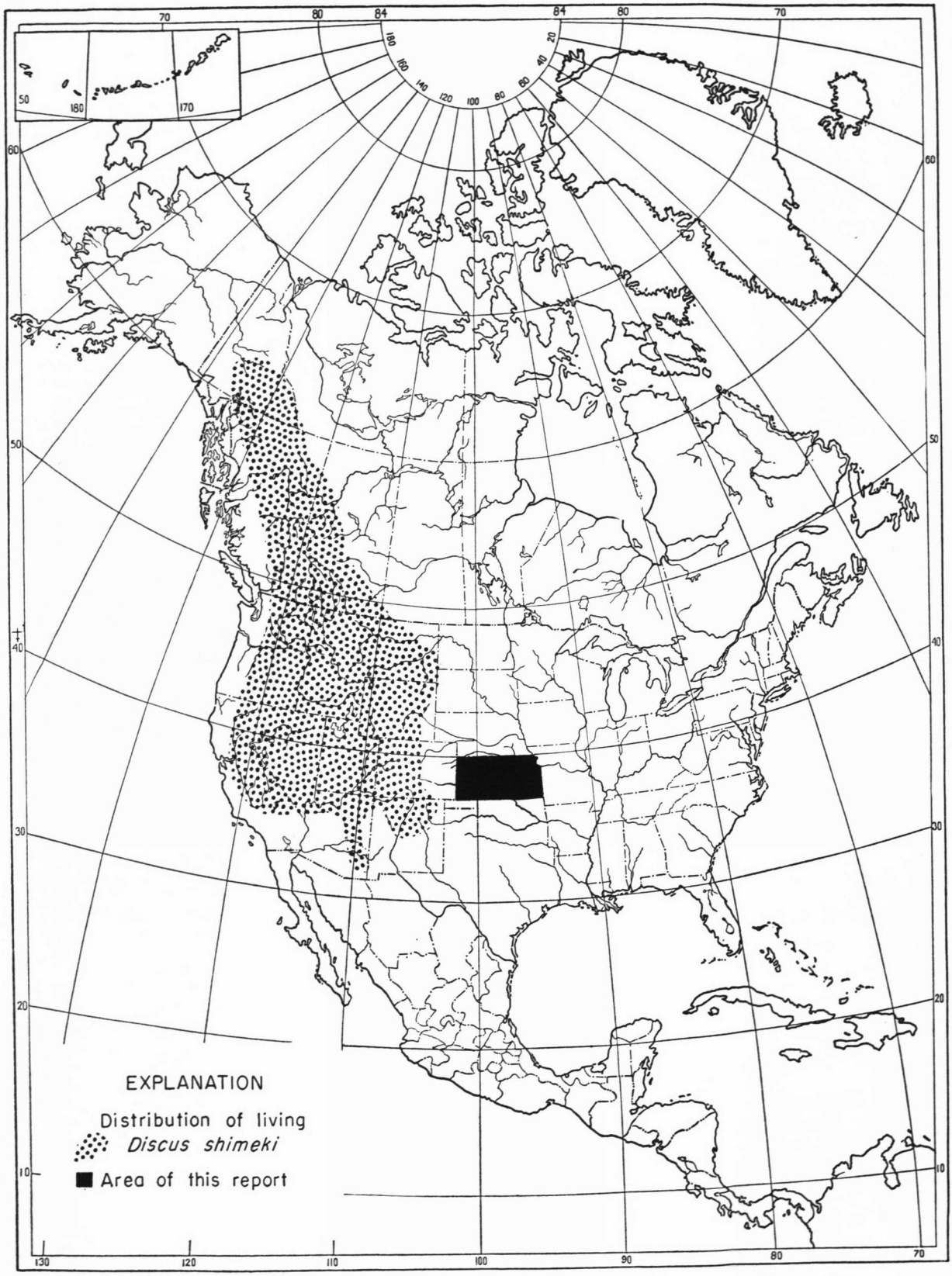


FIGURE 9.—Distribution of living *Discus shimeki* in relation to the area of this report.

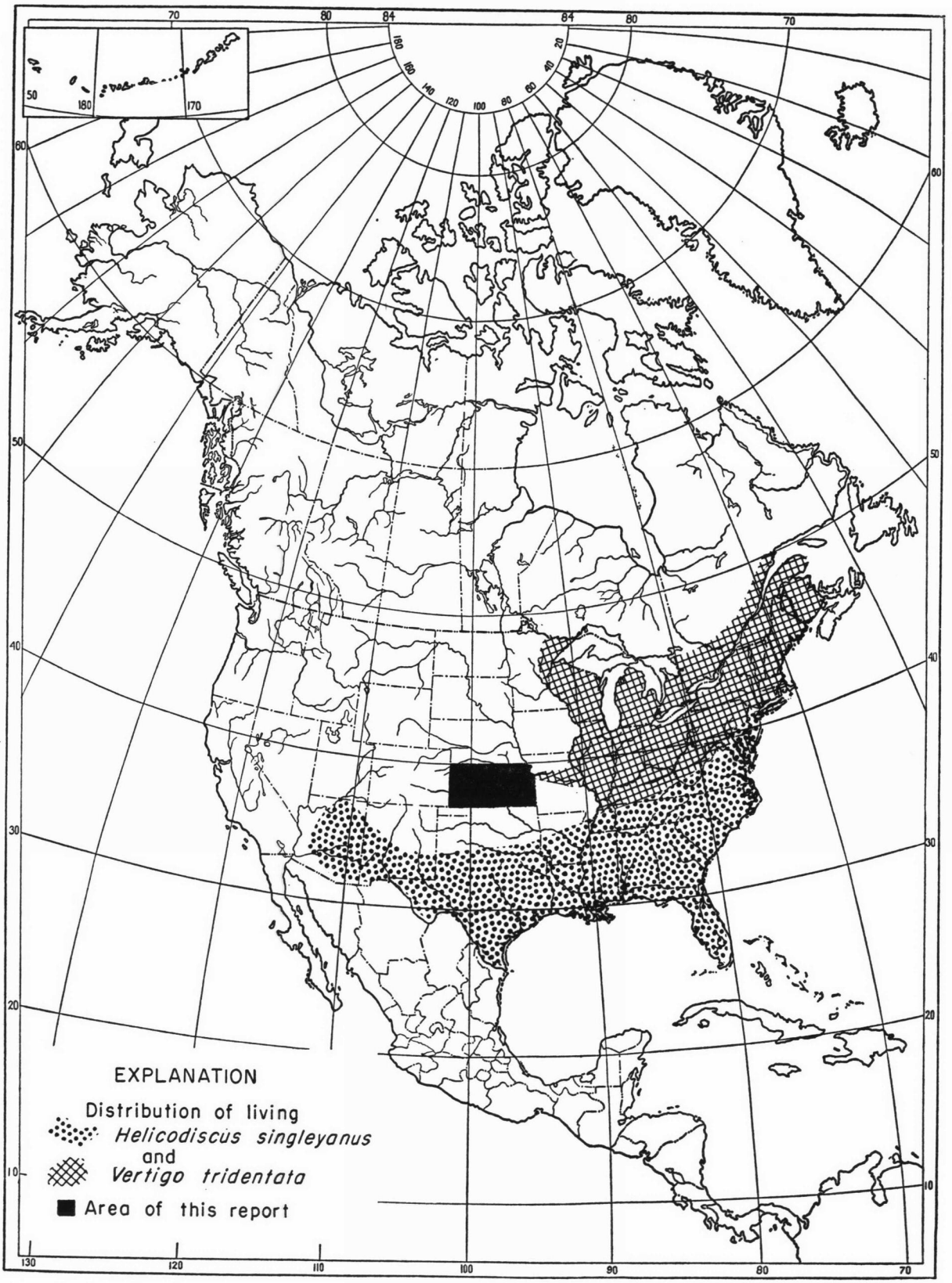


FIGURE 10.—Distribution of living *Helicodiscus singleyanus* and *Vertigo tridentata* in relation to the area of this report.

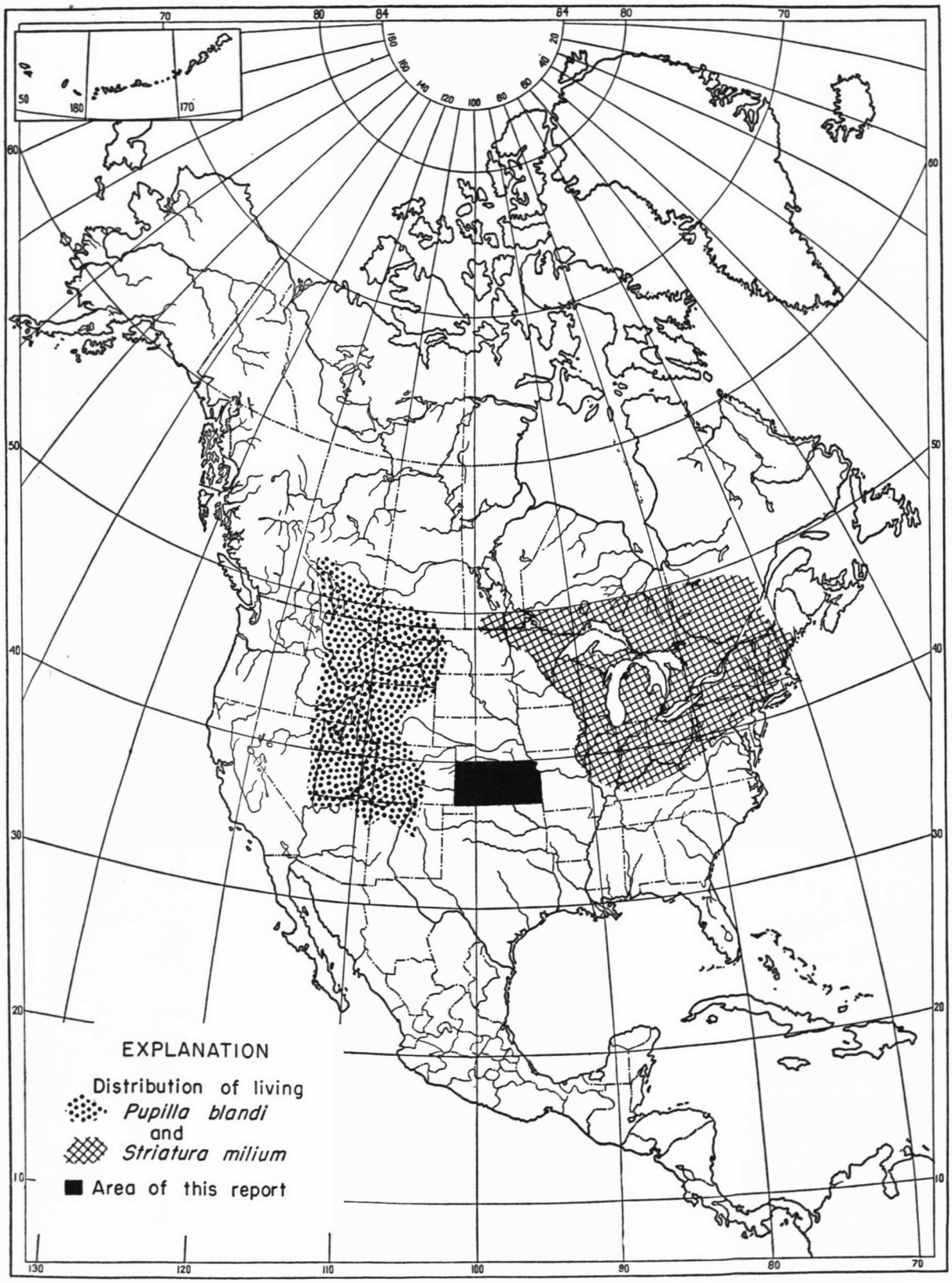


FIGURE 11.—Distribution of living *Pupilla blandi* and *Striatura milium* in relation to the area of this report.

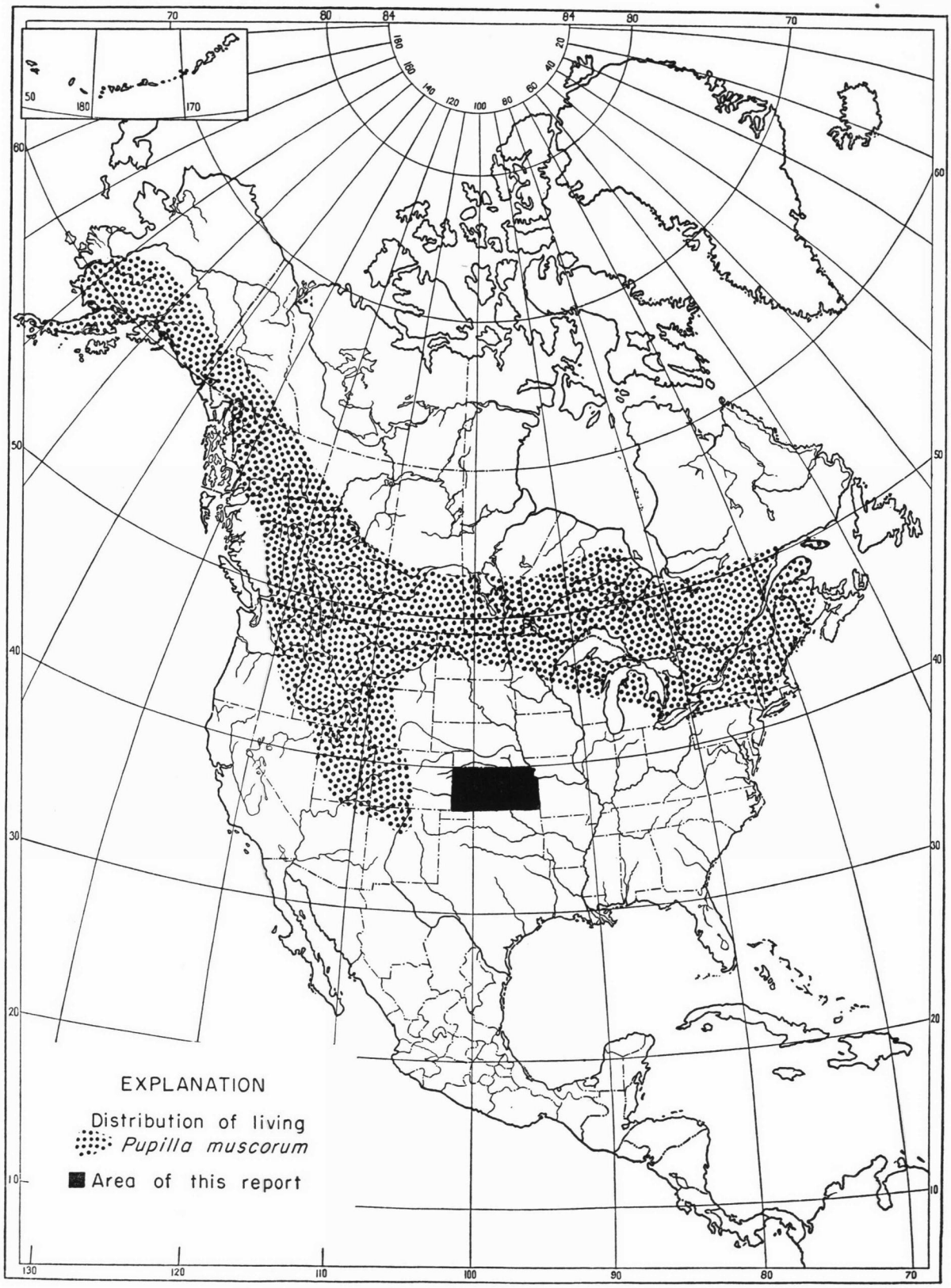


FIGURE 12.—Distribution of living *Pupilla muscorum* in relation to the area of this report.

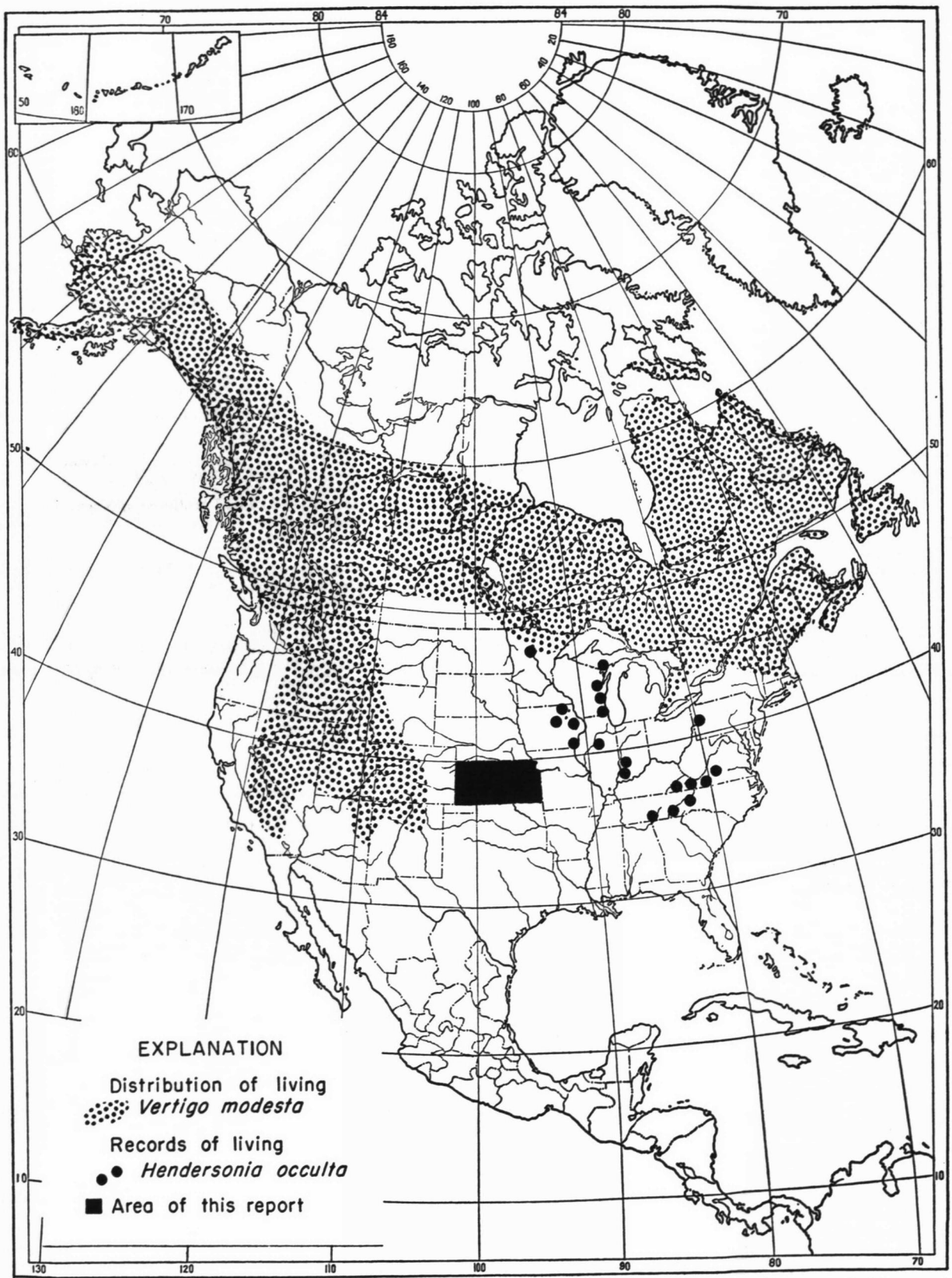


FIGURE 15.—Distribution of living *Vertigo modesta* and *Hendersonia occulta* in relation to the area of this report.

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